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EDUCATION AS THE PSYCHOLOGIST SEES IT

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PREFACE

The development of psychology in connection with education has been so marked in recent years that a summary of the main points at which educational problems are influenced by psychology should offer something of interest to the teacher as well as to the student. This volume affords a somewhat more concise survey of the field than most of the more recent books. It is written avowedly from the standpoint of the psychologist. It attempts to consider the problems of the teacher as they are presented to the psychologist,—in this case, however, a psychologist who has been some thirty years a teacher,—and as the facts developed by the modern science cast light upon them.

The book aims to indicate what we should expect the process of education to do for the child. This implies first, a knowledge of the nature of the child before his education commences; second, a study of the psychological processes which are involved in working the changes required; and thirdly, a summary of the methods that have been developed for the measurements of the progress that has been made in each of the school subjects.

It is assumed that earlier work in psychology has provided a knowledge of the more fundamental parts of the nervous system and the process of sensation. But the necessary data concerning these subjects may be inferred sufficiently from the material given to make the treat-

ment complete in itself. References to more extensive works are given at the end of each chapter, which, it is hoped, may stimulate to further investigation.

The preliminary discussion deals with the simpler statistical facts and methods necessary for an understanding of the distribution of abilities in average individuals. It also furnishes a basis for the discussion of statistical evidence for many of the problems that are to come later. This first part also considers the nature of intelligence and the factors that determine it, together with a briefer summary of what we know of the other mental characteristics.

The second general part is devoted to the specifically psychological processes and laws which the teacher must use: the facts and theories of instinct fundamental to many of the teaching operations; attention as it is related to special teaching methods and theories of education; the results of psychological experiment on memory, which are of great importance for the teacher. Perception receives much space because of the laws that have been developed in this subject for the comprehension of reading. The technical discussion of space, movement, time, and similar topics are omitted as of less interest to the teacher. A brief treatment of the more practical aspects of reasoning is included. Action is important in general, and receives particular notice from its connection with writing. Feeling and emotion are emphasized in their relation to discipline and mental hygiene. Modern psychological movements, especially the Freudian, emphasize these aspects.

A long discussion of formal discipline includes a rather full summary of the historical development of memory

training, and of most of the other phases of character or capacity that have received either experimental or statistical treatment. A last chapter gives a summary of the means of measuring the attainments of the child in each of the disciplines of the elementary schools.

It is hoped that the book may appeal to the teacher who is seeking to keep up with the most recent studies in psychology as it applies to educational problems, to the general reader who as parent or citizen may be interested in education, and also that it may be useful as a text in educational psychology for courses which give a relatively brief introductory treatment.

There remains the pleasant duty of thanking individuals and publishers who have given permission for the use of cuts. The indebtedness for factual material is too general to be acknowledged. I desire to thank Professor Woodworth and Henry Holt & Co. for the use of the cut illustrating the control of association; Houghton, Mifflin Co. and Professor Terman for permission to reprint the ninth year of the Terman tests; Professor Woody for permission to reprint his short arithmetic test; Dr. Ayres for reprinting his penmanship test; The Macmillan Co. and Professor Titchener for the use of Figure 8; The Macmillan Co. and Professor Gates for the use of three cuts from his *Psychology for Students of Education;* and The Macmillan Co. and Professor Griffitts for use of cuts from his *Vocational Psychology*.

W. B. PILLSBURY.

UNIVERSITY OF MICHIGAN,
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CHAPTER I

INTRODUCTION

Points of Contact between Psychology and Education.—The interest of the psychologist in education is primarily scientific. He approaches the problem with a knowledge of the capacity of the child and of the laws of mental life. His desire is to determine first the differences in capacity, so far as that capacity bears upon the learning of the child, of the individuals who are supplied to the schools. He also desires to use the schoolroom as a laboratory for the further testing of the laws of human action that he has developed by a study of older individuals working in the laboratory under somewhat artificial conditions. Assuming that the community demands that the child be taught certain things, he seeks to determine how they may be taught with the least effort.

Ends of Education Set by Society.—When the traditional demands of the community that certain changes be worked in the nature of the child are at variance with the possibilities as indicated by his general knowledge of human nature, he must indicate the difficulties and attempt to point out how far such demands may be attained and how far they must be modified.

Method may be Determined by Psychology.—In all that he says, the psychologist must use the same rules of evidence and methods of procedure that he uses in his own field. He must discard all conventional assumptions concerning the nature of the child, and the methods that should be applied. He must question each statement, must reach all of his conclusions on the basis of observed fact or experiment, must apply statistics where the results of experiments vary with the individual. Where evidence is lacking he must either withhold judgment or make tentative statements from general principles established in related connections.

We may distinguish four problems or fields in which psychological principles are of value to the teacher. First, we must know the nature of the child to be trained. Second, we must determine what modifications are demanded by the community. Third, we must know to what extent the desirable changes may be induced; and fourthly, the best methods of developing them.

The Nature of the Child.—The problem of the nature of the individual may be approached in several ways, and in each much knowledge has been accumulated. First there is the question as to the way in which the individual becomes what he is. Very broadly this raises the old familiar question of the relative importance of nature and nurture. At present, the biologists, including the psychologist, lean to the opinion that the individual is what he is very largely because of his inherited characters. He is what the characteristics of his two parents make him. The sociologist, on the other hand, still is inclined to believe that education and the influences that work upon him after birth have a large

part in determining his ultimate capacities. We must come to close quarters with this question before we can go far in a discussion of education. For if education or the influence of environment is valueless, obviously all that we can do is to turn eugenist and endeavor by selective mating to improve the qualities of the human species and then let these selected individuals work out their own salvation.

Instinctive Characteristics of the Individual.—A second problem in connection with the ultimate nature of the material to be worked with is a study of the innate qualities of all individuals. For if the particular heredity determines the specific differences of individuals one from another, the common descent of all from lower members of the animal series gives each child certain qualities that we must know as a basis for the development of the general cause of teaching. We can only work changes in the individual that are already latent in him. If we are to induce those changes we must take into consideration the character of the influences that are available, and the stimuli that appeal to him. We must understand the character of the individual and discover the influences that may be brought to bear upon him to induce the changes which education hopes to work in him.

Individual Differences.—A third problem that has come to be of vast importance in the light of relatively recent psychological discoveries is a study of the individual differences between children and also between adults, with little or no reference to the manner in which they may have been brought about. Only in the last fifteen years have we begun to see that there are

very marked differences in the capacities of individuals. Certain of these are the differences in what we call intelligence, which may be defined provisionally as capacity for the accomplishment of certain tasks in school work or in attaining physical and mental ends by the use of means not directly related to physical strength. There are other differences in the emotional characteristics of individuals. These are in part the qualities which make them liked or the contrary in their relations with their fellows. They also show themselves to be of importance in the ease or difficulty, the amount of satisfaction or dissatisfaction that the individual himself obtains from work or from the end which the work makes possible of attainment. This difference is very closely connected with the mental health of the individual and his probable duration of effort. A third factor which is of great importance in determining the efficiency of the individual is what we in popular terms call his will. By this we mean his capacity for continued work where the end is remote or not directly in sight, or when difficulties arise to make extreme effort needed. Individuals obviously differ in all of these ways and even if these characteristics cannot be changed, we must know them in order to select individuals for different modes of training, otherwise we shall attempt to train an individual for a task which is altogether beyond him. If he can be changed by education in any of these particulars, we should know that also in order that we may take proper steps to improve him in each of these respects. This problem of individual differences is one of the most important for all education.

How Far Can We Educate?—When we turn to the question as to the limits of educability, which we have seen to be involved also in the question of the nature of the individuals, we find that there has been much talk and little assured result. For that reason we must be very careful in our treatment at all points. For to go ahead on the assumption that one thing can be done and then to find that it cannot will waste the time of teacher and student and will discourage the latter when he discovers, if ever he does, that the results hoped for have not been attained. We may treat this problem in various ways. The most usual is to study the effects of education upon man in the mass, to compare the individuals who have been subjected to a given training with those who have not, in the hope of determining from this what can be expected from education. There are obvious sources of error in this procedure, but it is still the method most advocated by the orator, and by many men who are content with superficial considerations. A second method is the definitely experimental one. This requires that the individual to be tested as to his capacity in some one particular be subjected to a definite course of training and then measured again to see if he has changed in any way as a result of this training. Careful study of different capacities would in the long run determine what could be expected of education upon men of different types and capacities. Much may be made of this method, provided all sources of error are carefully provided against.

The determination of the second point,—what changes it is desirable to induce in the individual,—lies beyond the scope of psychology proper, and within the domain

of ethics, practical politics, and economics. But the relation of their appreciation to psychological principles, particularly to the social instincts, may be pointed out. It is also desirable to recognize them at the present because modern school practice seems at times to confuse them with the instinctive desires of the child, and forgets that while the child may set the limits of education, he should not determine what shall be taught. While the conditions upon which the decision of these matters rests is psychological, the absolute determination depends upon many other factors.

In brief, then, psychology as such should be called into consultation when the teacher asks what the capacities of the child are with which he must begin his work, the capacities that depend upon the general and specific inheritance of the child and upon the differences that exist between children so far as these are significant for education. He should be asked to determine how far the child may be trained in the ways that it is regarded as desirable to train him from social or ethical considerations and he may be asked what are the best methods of training him, so far as they depend upon principles that have been determined by the psychologist. In addition many problems occur to the psychologist who is also a teacher upon which he has an opinion as a member of the profession apart from any special knowledge that he may have as a psychologist. These latter opinions are to be taken for what they are worth as suggestions derived from observation and experience, which have not been reduced to scientific form, but which are nevertheless guided by the scientific method and limited by the scientific spirit.

General Effects of Psychology upon Education Beneficial.—It should be noted that the influence of psychological inquiry and of psychological observation upon education in recent times, has been to relieve it of much dogmatism, of much argument from general principles and common observation not controlled by specific factual record or exact measurement. In pre-psychological days educational principles were established either by common sense observations, by the prejudices of individuals who taught different subjects, or by deductions from the assumed nature of man. One was told not what is, but what must be, and it is generally observed that what must be is only a way of stating an opinion for which one has little particular evidence. In any argument one always states facts where one has them. When hard put to it for fact one who is sure of the conclusion falls back upon the statement that it must be, or if garrulous goes even farther with the statement that the nature of man is such that nothing else could possibly happen. In so far as the older work gives common sense interpretations of what was actually seen, much reliance is to be given to its decisions. Even at its best, however, there was much faulty analysis and the attribution of observed phenomena to the wrong one among many antecedents that were all equally immediate predecessors. In short, earlier educational theory and the resulting practice contained much that was correct and praiseworthy, mixed with many ingenious but faulty deductions and interpretations. Not all of its conclusions have been superseded by the modern methods, but much of it deserves little credence.

Psychologist Can Accept only Proved Facts.—The psychologist should approach all problems in the attitude of the scientist, that is, in the attitude of the skeptic who must be shown. He should question every statement no matter how generally accepted by current opinion, even by those who apparently have the best right to an opinion. Nothing should be accepted either because it is generally believed or because some great man has asserted it. Where tests are possible the matter in question should be subjected to test. Where actual experiment cannot be applied or has not been as yet and claims are made on the basis of school practice, these claims must be substantiated by actual statistics of the results obtained not by the familiar "we have all observed" or "I have frequently seen in my classes." The latter source of authority we are all too familiar with. So necessary is this attitude, and so frequently have the general beliefs proved fallacious that many of the investigators of experimental psychological facts as applied to education are not satisfied unless they prove that every generally accepted belief is false. This may itself come to be a source of error. Obviously an unprejudiced result demands a readiness to believe the probable quite as much as a willingness to accept experimental evidence that the probable is not actually true.

Without further preliminary discussion of what we intend to do or of preliminary definition of the terms which we are to use we may proceed at once to a discussion of the problems which we have laid down for ourselves one by one.

QUESTIONS ON CHAPTER I

1. How does the teacher need psychology?
2. What problems of education can be given a psychological answer?
3. How has psychology changed the attitude of the modern teacher?
4. Can psychology dictate what is to be taught?
5. Can it determine the methods of teaching when it is decided what should be taught?

REFERENCES FOR CHAPTER I

GATES: *Psychology for Students of Education.*
STARCH: *Educational Psychology.* Chapters I and II.
MCCALL: *How to Measure in Education.* Chapter I.
THORNDIKE: *Educational Psychology.* Chapter I.
PILLSBURY: *Essentials of Psychology.* Chapter I.
COLVIN AND BAGLEY: *Human Behavior.*

CHAPTER II

GENERAL PRINCIPLES OF DISTRIBUTION OF MENTAL AND PHYSICAL TRAITS

The Probability of Occurrence of Traits.—Much of what we have to say of traits in many connections implies general mathematical principles and methods. These must be given in relatively simple form, since we cannot presuppose on the part of the reader any knowledge of higher mathematics. The first of these principles describes the distribution of traits. It has long been known that where any physical trait of animal or man is studied, the distribution of that among a large group shows a definite relation between the absolute amount and the number of times it occurs. There is a tendency for all measurements of a character to group about one value. Were one to personify nature, it is as if some force were shooting at a target and the hits were grouped about the point aimed at. The smaller misses are much more numerous than the larger ones. In fact, the mathematical statement or curve which shows any chance distribution of characters is exactly the same as the distribution of shots about the center of a target when one is shooting at it.

The Curve of Probability or Distribution.—The difference is that in chance distributions in Nature the center of the target is represented by the average and the misses by the departures from that average. No one knows in advance what Nature may be assumed

to be aiming at, and of course there was never any conscious force to do the aiming. Nevertheless the results are similar. If one measure the height of a large number of men taken at random, it is found that they will group about some value which varies with the race measured. If the results are plotted with the number of instances or measurements on the vertical

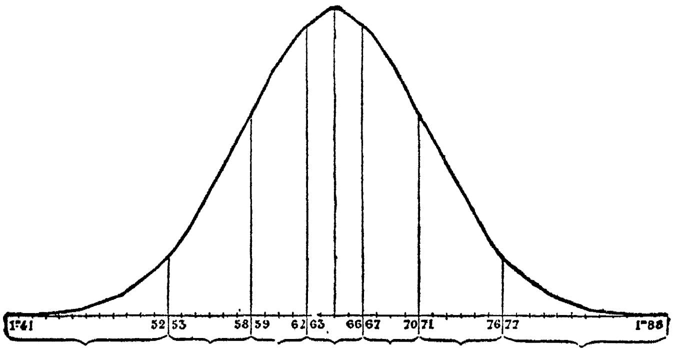

FIG. 1 —The distribution of stature among French soldiers. The distances on the horizontal axis indicate the height in centimetres, on the vertical axis, the number of men of heights between the figures printed below the line. From Bertillon: 'Instructions Signaletiques.'

axis, and the different heights on the horizontal axis, the curve is always similar. There is a marked elevation in the middle, and a gradual falling away to both sides which is very similar for all cases. There is always a symmetrical distribution, there are as many on one side of the average as the other. It is found also that there are approximately as many at a given distance from the average on one side as on the other, and there are always a very large number of very slight departures from the average and a very few of the relatively large departures.

Probability Curve Holds for all Traits.—This is what we call the normal curve of distribution, and has been found to hold both for mechanically chance distributions as the flipping of coins and also for all the deviations from the average that have been measured on unselected individuals. It holds for the size of flowers and length of leaves of a given species of plant, for the height of men, for the length of forearm and length of skull, in fact, for all measurements of materials that have not been in any way selected. Where there has been selection of any kind, the curve will not have this symmetrical character, but will be bent to one side, skewed, as it is called. This would be true of men selected for height for a special military organization; it would be true also where natural selection had been at work to eliminate all of one kind or to increase the units of another kind in the group. So general is the rule that unselected material always shows the symmetrical distribution that where one finds the skewed curve of distribution, one is fairly safe in assuming that the material has been in some way selected and can usually find evidence of such selection and sometimes can discover the agent that has been at work upon it.

Distribution of Intelligence.—The application for us of all this mathematical treatment is to prepare for the statement that so far as we have evidence mental qualities, intelligence in particular, are distributed in exactly the same way as are the physical characters. In studies of school children of the same age it is found that there are just as many who are a given distance above the average as there are the same distance below the average. The army tests of the large sample of

the population between 20 and 30 which passed before the examining boards showed that there were approximately as many who made scores a given distance above the average as there were who made scores the same distance below. It should be said that there is a certain

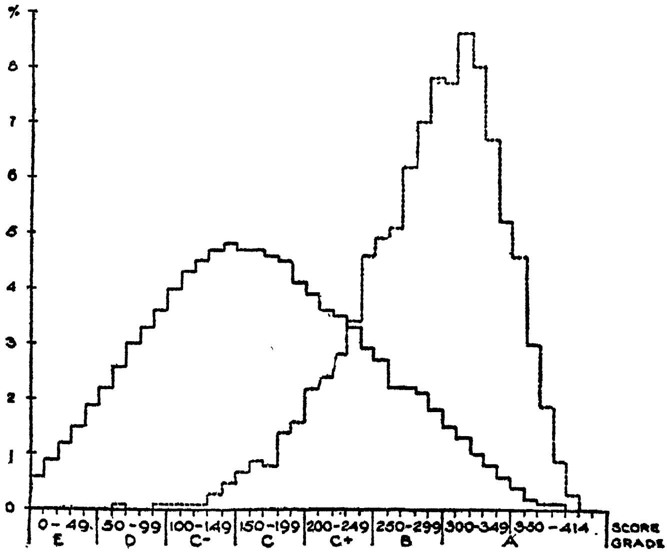

FIG. 2.—Shows the distribution of standing in Army Alpha test of 5,563 officers as compared with 63,647 enlisted men. The high average of the officers stands out clearly.

amount of arguing in a circle in this particular measurement because the measures themselves were chosen on the assumption that there was a symmetrical distribution in accordance with the normal probability curve. There is a certain check even in this, for once the measures had been graduated on the assumption of a normal distribution on one large specimen of the total, it was found that another sample, and in fact other samples

each composed of thousands of separate individuals, showed the same normal distribution. The tests made on children of the same age were checked against the average performance of different ages and showed the same symmetrical distribution.

Laws of Distribution Illustrated in School Grades—This law that intelligence is distributed in accordance with the general law of probability is at the back of the tendency to grade students in the universities by giving the highest mark A, *e. g.*, to only ten per cent of the class, while the second mark, B, is given to twenty per cent, and the middle mark, C, to forty per cent, while the very worst mark, E, is assigned to the same number as that given A. Where the individuals are selected, as children in the higher grades usually are, this rule would not correspond to the facts. The distribution would be skewed towards the better marks, and more should be given the higher than the poorer. This is in fact the way the marks are usually assigned in practice, although most teachers under the influence of the assumption of normal distribution are inclined to think that it is a result of the teacher's kindliness or dislike of offending rather than of the selection of the students. At least in more advanced grades and in more advanced classes there is bound to be selection, and with selection there would naturally be found a larger percentage of good marks and so a skewed curve.

The Relation of Distribution of Two Traits.—In addition to a knowledge of the way in which different traits are distributed in the general population, it is frequently desirable to know how two traits are related one to another. In very much of biological work in

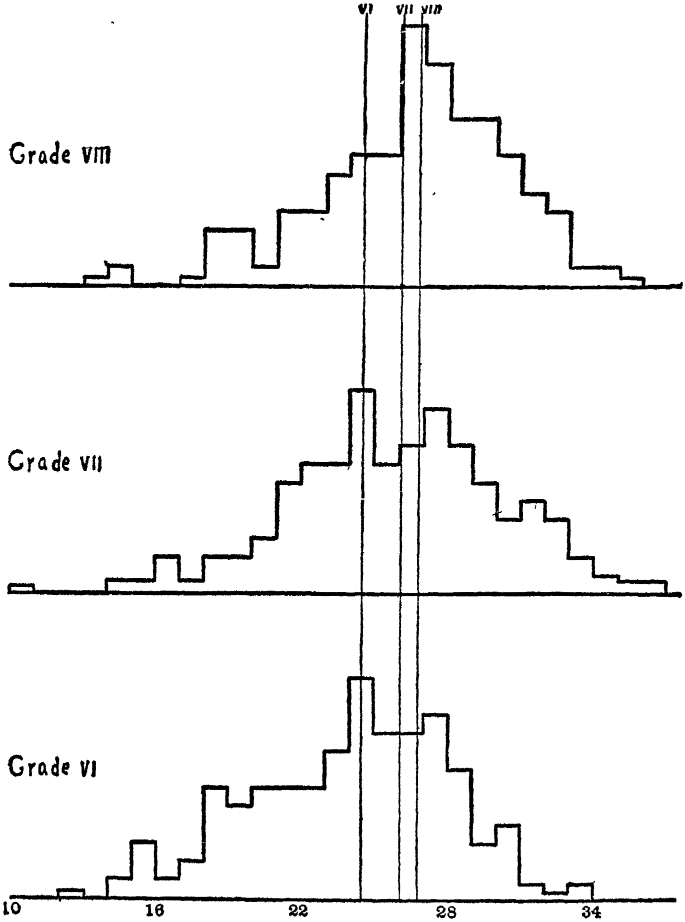

FIG. 3.—Frequency polygons for ability in division. There are 234 pupils in the grade 6 group, 307 in grade 7, and 272 in grade 8. The vertical lines headed by VI, VII and VIII indicate the average abilities of the respective grades. Note how slight the differences between the grade averages are and how much each grade overlaps the others. (From Kruse, "The Overlapping of Abilities in Certain Grades," p. 41.) After Gates; "Psychology for Students of Education."

general, and this holds equally, if not especially, of mental traits, we cannot trace very clearly the actual causal relations between two forces that may be assumed to go together. Still we do believe that where two traits are found together in a sufficient number of cases there may be some unknown force which accounts for the fact that they occur together. This holds almost completely of the processes involved in heredity. One knows at present so little of the actual chemical and physical forces that make possible the transmission of a quality from parent to child that it is useless to speculate as to what makes heredity possible. Nevertheless, one desires to know more accurately than can be determined by mere observation the probability that a trait which appears in the parent will appear in the child, and in what degree it is likely to appear in the child.

Cœfficient of Correlation.—This measure is found in the coefficient of correlation which makes it possible to state the degree of similarity in a single figure. If one desires to know how far the length of forearm of a child is determined by the length of forearm of the father, one can measure it or state the probability in terms of the coefficient of correlation. The coefficient of correlation is a value which can be determined arithmetically as follows. Arrange the lengths of the forearms of the fathers in a series with the greatest value at the top. Similarly arrange the values of the forearms of the sons in order with the largest value at the top. Then take the average, and in a third and a fourth column give the differences between each value and the average, one column for the fathers and one for the sons. Then in a fifth column multiply the deviation of

the father from the average by the deviation of his son, respecting the signs. That is, if one is positive and the other negative, one is above the average and the other below, the product will be a minus quantity. If both are on the same side, they will be positive, and the sum of the positive values will be larger the farther both are from the average on the same side, *i. e.*, the more similar are the fathers and the sons. The sum of the negative values will also be larger the farther each is from the average, and so the more unlike are the pairs of individuals. In a sixth column place the square of the deviations for the fathers and in a seventh the squares for the sons. The next step is to add the products in the fifth column algebraically, subtracting the negative values from the positive. This gives a value which will be large when the fathers and sons are alike, and small when they are different. Then add the squares in the sixth column and in the seventh and extract the square root of each sum.

Now if we divide the sum of the fifth column by the product of the square roots of the sixth and seventh and by the number of cases we shall obtain a fraction that constitutes the coefficient of correlation.

That this fraction measures the similarity between the two groups with reference to the quality given, or at least that it varies with the degree of similarity may be seen by inspection. For if fathers and sons were all in the same order, if the father who had the longest forearm had a son who also had the longest forearm among the sons, and the father who stood second had a son who stood second, the products of the two columns would be identical, and the fraction would be one. This

is the highest degree of similarity. If, on the other hand, the father who had the longest forearm had a son who had the shortest, and the father who stood second from the top had a son who stood second from the bottom, etc., the values would be the same save that the first value would be negative, and hence the quotient or fraction would be -1. That would mean that having a father with a long forearm would tend to induce a short forearm in the son, and in the maximum degree.

In practice these coefficients always lie between $+1$ and -1. If they are zero it means that there is no connection whatever; if they are small it means a slight connection; if large a considerable relation. Usually to have any significance they must be in the neighborhood of forty, unless one has used a very large number of instances in drawing the deductions or determining the relation. As a matter of fact, most inherited physical traits show a coefficient of correlation of from .4 to .5 between the fathers and sons.

If one should interpret this in terms of cause it would mean that the forces involved in heredity might be regarded as in part due to the influence of something in the germ cell of the father that represented the length of his forearm, and that that something reacted to determine the length of the forearm of the son. But in addition to this factor, whatever it may be, there were other forces which were irrelevant to the forearm of the father. One cannot say, unfortunately, exactly what the probability is that a son shall have just the qualities of his father or what the probability is that he will depart from them by any given amount. In spite of the dense ignorance that exists concerning

the mechanics of the matter or even the statement of probability, this coefficient of correlation does enable us in practice to detect connections that are more than chance. The similarities between the two are probably to be regarded as the result of causes working, we know not how, to make a son like his father, in the instance we have chosen, or to bring together two qualities or capacities to make an individual of a given character.

In education, we are more interested usually in the way in which two measurable traits may be likely to be combined in a given individual. We shall have occasion to study the connection between intelligence and persistence or good will. We shall see that Webb found that there was a probability that if a man were high in intelligence he would also stand high in persistence. This he stated on the basis of the coefficient of correlation by saying that there was an *r*, which is the symbol for coefficient of correlation, between intelligence and will of .45. One might in the same way measure any two qualities which seem to be related or which any one thinks might be related. It would be well for the reader to work out on the scheme given above the *r* between intelligence and stature. It is asserted that tall men on the whole are more intelligent than short ones. If you will obtain the height in inches or centimeters of fifty adults and then take some measure of intelligence, if they are students, obtain from the records of the university their average standing, one can determine the *r* and from that decide whether or not there is anything in the assertion. We shall have occasion to use this measure of relation in many cases. For when one desires to leave argument

for fact, this *r* gives about the only means of ascertaining and stating the facts. We can also state the relation between different measures of intelligence and different traits and capacities. In fact, it has a very wide application in educational psychology and in psychology and biology generally.

REFERENCES FOR CHAPTER II

Rugg: *Applications of Statistical Methods to Education.*
Kelley: *Statistical Method.*
Thorndike: *Mental and Social Measurements.*
Starch: *Educational Psychology.* Chapter III.
Brown and Thompson: *Essentials of Mental Measurements.*

CHAPTER III

THE ORIGINAL NATURE OF THE CHILD

We may approach the problem of the original nature of man from two points of view. First is the descriptive in which we endeavor to indicate how one man does actually differ from another. From the standpoint of ordinary educational practice we can give a classification of the individual in all the ways that are important for the schools, together with methods of determining to what class the particular individual may belong. The other approach is to assume that there are differences and then to attempt to discover what made those differences and how they may be changed or at least whether and in what degree they may be changed. We shall attempt the first task in this chapter since it is necessary to know what the differences are before we can say much about their origin.

Are Individuals Different?—The problem of individual differences has been definitely appreciated only comparatively recently, in ways that shall be valuable for practice either in education or politics. Of course every one has known that individuals must be different, but many political and practical considerations have compelled us to keep that knowledge in the background, at least so far as the actual people we come into contact with are concerned. The older aristocratic form of government insisted upon the superiority of certain peoples, but these superiorities, for the most part, were of an

intangible sort and in many respects were in non-essentials. The king was divine, but few had the hardihood to assert that all kings were more intelligent than their subjects. The divinity was made to consist in indefinable attributes that could not be submitted to actual test, for it would be disastrous for the king to fail in the test, disastrous not only for him, but for the established order as well. Similarly the difference between a gentleman and the common herd is more in non-essentials of the use of table implements and of language than of essentials of strength or of intelligence. While it may be true that intelligence and gentlemanliness on the whole go together it would not be polite or safe to make belonging to the class of gentlemen depend upon an actually measurable quality like intelligence or capacity of any kind. Too many of our friends and relatives might be excluded, even if we ourselves were able to pass the test. So all of these class distinctions were left very vague and were not identified even in thought with any specific capacity or quality.

Early Educational Theory Overlooked Differences.—In school practice certain pupils have always been recognized as dull, others as brilliant, but the political principle of democracy and the practical need for preventing the teacher from finding an excuse for failure in the character of the pupil seemed to prevent raising these observations to the level of a general principle. Probably, too, the fact that, on the whole, society is arranged in such a way that we come into contact for the most part only with individuals of our own kind has an important influence in preventing us from recognizing the great differences in capacity that really

exist. Only in the schools do we meet intimately individuals chosen from all levels of intelligence, and even in the schools only the lower grades contain an entirely unassorted representative lot. There we are content to assign most of the differences to immaturity or to differences in maturity. Only the modern measurement methods gave any idea of the great differences that exist everywhere in society.

The Development of Intelligence Testing.—The methods for testing intelligence were first used in a tentative way by Cattell and others and at Columbia, but the real beginning may be said to date from the experiments of Binet about 1905. Binet was asked to measure the intelligence of individuals who were to be admitted to special schools for the backward children because, without asking whether it were possible, a commission had ruled that no one should be admitted before he had had his intelligence tested. Binet began by making relatively rough tests of a general character, but soon hit upon the idea that one might compare the intelligence of an adult or any one else with the intelligence of children of different ages. This was on the assumption that the child increases in intelligence from zero to his maximum. To accomplish the measurement of the intelligence of the child he devised a series of tests of increasing difficulty and determined by tests upon several hundred children in the schools what could be expected of a child of each age from three to fourteen. These tests have been checked on large numbers of children and revised until we have a very satisfactory knowledge of what the average child of each age can accomplish in them.

Mental Age.—Intelligence Quotient.—When it is desired to determine the intelligence of any child or adult, he is asked to comply with the demands of the test and from his success or failure one can determine the ages of the child he most nearly approximates in intelligence. This is called for convenience his mental age. The tests in their best form can be seen in Terman's treatise.[1] It would require too much space to give them with their directions here. Another measure that is useful and should be understood is the intelligence quo-

FIG. 4.—Binet-Terman Test for Year IX.

1. Name the day of the week; the month; the day of the month; the year.

2. Arrange in order five weights of 3, 6, 9, 12, and 15 grams each. Must be correct twice out of three times.

3. Solve an arithmetical problem involved in making change.
   a. If I were to buy 4 cents worth of candy and give the storekeeper 10 cents, how much money would I get back?
   b. If I were to buy 12 cents worth and gave the storekeeper 15 cents, how much would I get back?
   c. If I bought 4 cents worth and gave the storekeeper 25 cents, how much would I get back?

   The test is passed if two out of three are answered.

4. Repeat four digits backward: (a) 6–5–2–8; (b) 4–9–3–7; (c) 3–6–2–9. One out of three must be correct.

5. Make a sentence of three words that are given.
   (a) Boy, ball, river.
   (b) Work, money, men.
   (c) Desert, rivers, lake.

6. Make three rhymes for each of the three words: day, mill, spring. Two out of three must be correct.

[1] Terman: Measurement of Intelligence.

tient (I. Q.). This was introduced by Terman and is defined as the mental age divided by the chronological age. The advantage of this measure lies in the fact that the relative intelligence remains on the whole approximately constant throughout life. Thus if a child of four has a mental age of three his intelligence quotient will be 0.75. If at eight he has advanced, as he will on the average, to a mental age of six his intelligence quotient has not changed. In general, children have approximately the same intelligence quotient throughout life although their mental age increases with their chronological age.

The Army Group Tests.—Other methods of measuring the mental age or the intelligence of individuals have been devised that may be applied to a number at once rather than singly. The most complete was the Army Intelligence Tests developed by a group of psychologists on the basis of a scheme proposed by Otis. These are of two types, the Alpha tests for individuals who can read and the Beta tests for illiterates. The Alpha tests provide a series of blanks, which the recruits were asked to fill out under the instructions of a director, and as many as two hundred could be given the tests at once. The tests themselves consist of arithmetical problems, of testing whether simple statements for which the individual should obtain the information from everyday life, were true or false, tests of ability to follow directions and similar problems which should test the ability to use knowledge that almost any one should have. These tests have been fully standardized, for they were applied to nearly one and three-quarter million recruits. One knows fairly accurately what

FIG. 5.—Sample Army Test.

TEST 2

Get the answers to these examples as quickly as you can.
Use the side of this page to figure on if you need to.

SAMPLES
1 How many are 5 men and 10 men? Answer (15)
2 If you walk 4 miles an hour for 3 hours, how far do you walk? . . Answer (12)

TEST 3

This is a test of common sense. Below are sixteen questions. Three answers are given to each question. You are to look at the answers carefully; then make a cross in the square before the best answer to each question, as in the sample

SAMPLE
Why do we use stoves? Because
☐ they look well
☒ they keep us warm
☐ they are black

Here the second answer is the best one and is marked with a cross. Begin with No. 1 and keep on until time is called.

TEST 4

If the two words of a pair mean the same or nearly the same, draw a line under *same*. If they mean the opposite or nearly the opposite, draw a line under *opposite*. If you cannot be sure, guess. The two samples are already marked as they should be.

SAMPLES
good—bad .... same—opposite
little—small .... same—opposite

TEST 5

The words A EATS COW GRASS in that order are mixed up and don't make a sentence; but they would make a sentence if put in the right order: A COW EATS GRASS, and this statement is true.

Again, the words HORSES FEATHERS HAVE ALL would make a sentence if put in the order ALL HORSES HAVE FEATHERS, but this statement is false.

Below are twenty-four mixed-up sentences. Some of them are true and some are false. When I say "go," take these sentences one at a time. Think what each would say if the words were straightened out, but don't write them yourself. Then, if what it would say is true, draw a line under the word "true"; if what it would say is false, draw a line under the word "false." If you cannot be sure, guess. The two samples are already marked as they should be. Begin with No. 1 and work right down the page until time is called.

SAMPLES	a eats cow grass	true. .false
	horses feathers have all.	true .false

TEST 6

SAMPLES	2	4	6	8	10	12	14	16
	9	8	7	6	5	4	3	2
	2	2	3	3	4	4	5	5
	1	7	2	7	3	7	4	7

Look at each row of numbers below, and on the two dotted lines write the two numbers that should come next.

TEST 7

SAMPLES	sky—blue :: grass—**table**	**green**	**warm**	**big**
	fish—swims :: man—**paper**	**time**	**walks**	**girl**
	day—night :: white—**red**	**black**	**clear**	**pure**

In each of the lines below, the first two words are related to each other in some way. What you are to do in each line is to see what the relation is between the first two words, and underline the word in heavy type that is related in the same way to the third word. Begin with No. 1 and mark as many sets as you can before time is called.

TEST 8

Notice the sample sentence:

People **hear** with the **eyes** **ears** **nose** **mouth**

The correct word is **ears**, because it makes the truest sentence.

In each of the sentences below you have four choices for the last word. Only one of them is correct. In each sentence draw a line under the one of these four words which makes the truest sentence. If you cannot be sure, guess. The two samples are already marked as they should be.

SAMPLES	People **hear** with the	**eyes**	**ears**	**nose**	**mouth**
	France is in	**Europe**	**Asia**	**Africa**	**Australia**

The times allowed for the eight parts were as follows;

Part	1,	135 seconds (approximately)
"	2,	5 minutes
"	3,	1½ minutes
"	4,	1½ minutes
"	5,	2 minutes
"	6,	3 minutes
"	7,	3 minutes
"	8,	4 minutes

These time-limits were determined empirically, to give the best distribution of scores. In most of the tests the tasks were of gradually increasing difficulty. Therefore the score is not so dependent upon pure speed as many have supposed.

The score is the sum of the points earned in the eight tests. *For army purposes* it was found convenient to assign latter rating as follows:

SCORE	RATING
135–212	A
105–134	B
75–104	C +
45– 74	C
25– 44	C –
15– 24	D
0– 14	D –

score the average man can make in them, and how success in them compares with success in many of the professions and occupations of life. It was also found possible to determine what scores would be made on them by individuals of any given mental age as measured by the Binet tests. Thus one can use them either to measure the mental age or the relative intelligence as compared with mankind in general as represented in America.

The Distribution of Intelligence.—The results of the tests taken together indicate that men have practically all grades of intelligence. Those who are known as idiots proved in Binet's tests to have a mental age of less than three. They must be cared for in institutions for they cannot even perform the simplest functions for themselves. Individuals from three to seven are ordinarily known as imbeciles. They can do the simpler things required for their own care, but do not get on well in the community, although a fraction of one per cent were represented in the army draft. They can be used as servants under direction, but should have

institutional care because of their likelihood of committing crime and the uncertainties of making a living. The groups from seven to twelve, or more probably, eleven, are known as morons. They can support themselves, in fact about twenty per cent or more of the population seem by the army tests to be found in this group, but unless their habits are carefully formed, they are likely to become criminals and they contribute from twenty to fifty per cent of the paupers and ne'er-do-wells of the community. When trained they are a valuable element in the industrial community. Tests made in factories indicate that many of the more mechanical operations can be performed by them quite as well as by the more intelligent. In fact for the monotonous type of machine work they are more contented workers and in some cases even more successful than the individuals of higher intelligence.

Selection of the Intelligent in the Schools.—The army tests showed that there was a close correlation between the amount of intelligence and the amount of schooling obtained by the average citizen. This is readily understood. A child who has not sufficient intelligence to do the work of a grade becomes dissatisfied and will take the first opportunity offered by the law or his parents to leave school and go to work. Only the more intelligent continue in school. Only the more intelligent twenty-five per cent enter high school, and only a quarter of those go to college. As a result, tests of high school students show that they are all of an intelligence quotient near one or higher and most university students have a considerably higher quotient. In terms of the army grading in which the highest five

per cent were graded A, the next ten per cent B, and the next twenty-five per cent C+, most college students would be found in the A or high B grade, the high school students in these three higher grades, and the lower levels of intelligence would be found only in the lower grades of school.

School Failure and Mental Deficiency.—In the schools, too, much use has been made of the intelligence measurements. Before the Binet tests had been invented, it was noticed that a considerable portion of the children were constantly taking subjects and grades over again. Sometimes these children were looked upon by the teachers as unwilling or at most as a little dull. When the tests were applied it was seen that most of them were below the normal intelligence for the age. The intelligence quotient was below 1. No matter how hard they worked or how they were stimulated they still fell behind. In the school routine they were frequently passed on to a higher grade after they had repeated an earlier one, but tests of what they had accomplished showed in many cases that they had not really learned what they should from that grade even with two repetitions. They were passed on because the teacher did not want to bother with them longer or because she thought that the parents would expect them to be promoted or on one of a number of equally irrelevant excuses. With the development of tests they now can be discovered early and put in classes by themselves where they can be taught by different methods what they can be taught of the regular school curriculum and then can be trained for manual vocations in which they have a chance of success. Obviously

it is of no use attempting to teach subjects which require a high degree of intelligence to individuals of lower grades of ability. It is a waste of time for the pupil and for teacher alike.

The Schools and the Superior Child.—Similarly it is of great importance to the system and to society that students of greatly superior ability should be recognized early and given the special attention that shall fit them as quickly as possible for the higher places which they will undoubtedly occupy in the community. Whipple has shown by practical trial that children selected by tests as in the upper ten per cent of the general population in intelligence may save one year in three in the ordinary school curriculum and learn as much as the ordinary child in the regular routine of the grades. In these days when the pressure to finish professional training is manifesting itself everywhere, a saving of three years in the training of the physician would permit him to enter practice at twenty-four instead of twenty-seven, and the lawyer to leave the law school at twenty-two rather than twenty-five. This would be a great aid to the man and to the clients or patients who are in need of his services. Probably, too, it would have a good effect upon the schools to have all of the dull, all of the average, and all of the bright children together in classes. It would add interest to both sides, would save the dull child from too much discouragement and the bright child from too much elation over his performances, unless it should prove that mere being set aside for the brighter group shall be taken as a sufficient compliment to induce conceit.

What Intelligence is.—This difference in what we call

intelligence is the most important and best known of the differences between individuals. It leads one to ask what is meant by intelligence, the capacity which we have assumed as the basis of the difference. On this point we have not so much agreement as might be desired. Roughly it is the capacity for success in school and in life, so far as that depends upon the mere ability to acquire and use knowledge. The tests measure what we ordinarily call memory, the capacity for ease of learning and retention. All of the tests involve trials both of immediate and delayed memory, or memory for ideas and rote learning. They also involve ability to use what is remembered in new connections. The Binet tests emphasize particularly ingenuity in certain constructions. Both of these would be involved in what we popularly and technically call reasoning. Something of perception with the interpretation of what is perceived also comes into play, to say nothing of the processes of persistence under difficulties and similar processes that would be ordinarily classed under volition or emotion, but which cannot be eliminated from any activity whatever.

Theories vary from taking intelligence as a definite common factor which is involved in all activity and is regarded as a whole, set apart more or less from all other activities, much as was memory or will in the older psychology, to regarding it as a complex or composite of a number of different capacities in which retention and the capacity to control recall would be part but to which would be added all of the processes that pass upon the constructions as well as determine the readiness with which constructions might be made.

Recent work has tended to give over analysis and be content to treat it as a whole with little theorizing upon its nature. This probably will not last for long. One must in time become interested in defining and in analyzing the dependencies and relations of the capacity even if the reasons for developing it are only practical.

Success in the Tests and Success in School.—Meantime we have evidence that the sort of capacity implied in the tests is of great value in various practical ways. Speaking generally it is closely related to ability to succeed in school work. Here the connection is not absolute when dealing with individuals in the same general grades of intelligence, but does hold very closely of individuals of markedly different grades. There is not a very close relation between the grades obtained in the army intelligence tests and the grades obtained in college. This means, however, merely that the differences that can be detected in a half hour or an hour by tests must be greater than those that show themselves in the work of the courses as marked by grades. The tests are sufficient, however, to determine in the general population whether an individual belongs in the class that should be permitted to go to college or to enter a profession.

The Score in the Army Tests and Education.—When checked up against the amount of schooling obtained, the army tests showed a close connection. This proves two things, probably: first, that the individual's capacity for learning or doing the work required in the educational system is measured somewhat accurately by the tests, and secondly that the individual

on the whole goes as far in the school system as he has the ability to. When we ask whether the capacities measured by the tests have any relation to performance in everyday life, we have three positive indications of a close dependence: (1) the relation between the performances in the army and the tests, (2) the relation between success in school and success in life, and (3) the relation between the intelligence as measured by the tests of the different trades and professions represented in the draft. In the first place, the relation between success in life and in schooling seems relatively close if by success we mean fame. As a measure of distinction, inclusion in some current work of biography is ordinarily taken as a standard. It has been found by count that some seventy per cent of the men in "Who's Who," generally accepted as the authoritative current biography of men of distinction in America, are college graduates or attended college. It is shown even that there is a close relation between success in college and likelihood of being included in the list of people well enough known to be mentioned in the volume. It seems that a man who is in the upper fifth of the class is five times as likely to be listed as those who obtain lower grades.

Army Tests and Military Capacity—The army tests showed that almost all of the soldiers who were marked as poor by their officers on the basis of capacity for military service obtained very low grades in the tests. On the other hand, the men chosen for promotion to the grades of non-commissioned officers and to be sent to the officers' training camps and schools ranked relatively high in the tests. All the cross checks that were made showed that the capacities involved in the

tests were important elements in making a man a useful soldier. They would not, of course, measure courage or neatness or other qualities that were important to the soldier, so that the connection is as close as could be expected. (See Fig. 2, p. 13).

Army Test Scores and Civilian Calling.—When rated by the occupations from which they came in civilian life, there was also a close connection between the tests and the intelligence that might be expected of the occupation. The men that averaged lowest in the tests were the common laborers who would require least intelligence in their daily work, and are also among the lowest paid. The groups that were required to use more intelligence in their occupations also did better in the tests. Skilled mechanics stood higher than the unskilled, and the clerical workers of all types did better than the skilled tradesmen. Highest of all were the school teachers, the Y. M. C. A. secretaries, and the engineers.

An interesting special test of the medical men brought out the point that success in the profession was closely related to the qualities that were brought out in the mental tests. There was a surprisingly low grade made by the medical officers in all of the different groups. They stood lower than any of the other officers, even including the related groups of dentists and veterinary surgeons. When studied more thoroughly it was shown that higher ranks of medical officers did better than the others. Comparison of the grades and the earnings of the medical officers before they entered the service showed that the men who took the lower commissions were men who had never been very successful in their

professions. Apparently the men who first applied for commissions were on the whole men who had not been getting on very well in their regular practice, and who increased their earnings by going into the army. The specialists who went into the higher ranks were chosen men and their intelligence records showed that they did much better in the tests as well. On the whole, every test applied shows that what is measured by the tests is a quality which is essential to success as measured by reputation, and even by average earning power.

Intelligence Unnecessary in Routine Work.—This holds particularly of the professions and the occupations that depend upon brain rather than brawn. For the lower occupations that require only mechanical skill and quickness, there is no such close relationship. Tests made of operatives in a Connecticut silk mill indicated that there is no relation at all between intelligence and weekly earnings on the piece system of payments. For the work of moving spools and tying threads a person of low intelligence does just as well as the person of higher intelligence. This may be due to the disinclination of an intelligent man to the monotony of the routine, or it may mean merely that a minimum of intelligence is required, and given that, skill is merely a matter of repetition and intelligence contributes nothing, although it is no real detriment. Wherever any thinking is required, as in all supervision or even in clerical work, the relation between success measured in any of the usual ways and the results of the tests is positive. So that whatever intelligence may be, it is something that is desirable for all but the most mechanical occupations, and it does no harm in them.

The Differences in Intelligence of the Sexes.—Much discussion is given to the question as to whether there is a regular or constant difference in intelligence between boys and girls, or men and women. In general it appears that girls do a little better in school work, while men attain the greater distinction in after life. In the Binet tests, too, according to most authorities girls have a slight advantage. Burt found about a third of a year difference in favor of the girls at all ages but ten. Yerkes and Bridges found a less constant advantage for the girls, but still a prevailing one at most ages. Burt connects the advantage of the girls with their general superiority in reading and writing and other literary studies in school. The girl ordinarily leads a more sheltered existence and must fall back for amusement upon reading and similar occupations, while the boy sees more of life and business. Correspondingly the boy does better in arithmetic and in manual work.

More theoretical explanations argue that the girls, while more intelligent, on the average, group more closely about that average while the male is more variable. On this theory the best boys are better than the best girls. This, if true, would explain the greater success of men, or at least that the more prominent positions are held by men, but the observed facts are not altogether in accordance with the assumption. Another suggestion is that girls mature more quickly than do boys, but that they do not continue to develop so long and so the adult woman is not so intelligent as the adult man. The differences are so slight that the early advantage of woman can probably be explained by the habitual and conventional occupations, while

man's greater success in after life is quite explicable from the social conventions which give him greater opportunities, aided by his greater physical strength. The only important result of the experiments is to show the great similarity between the sexes.

Measurements of Mechanical Skill.—Of the other qualities of the man, we know relatively much less than we know of intelligence either theoretically or practically. Some success has been had in the measurement of mechanical skill. In the vocational guidance bureau of Cincinnati, Mrs. Woolley devised or applied some tests of rate of tapping, of steadiness and quickness of reaction which showed that there were characteristic differences between the children that correlated with their success in work later. On the whole she was of the opinion that mechanical ability as she measured it and intelligence were in general independent although they tended to be associated. On the basis of her results she suggested that we could distinguish four types by combining these two capacities. There were first individuals who had neither intelligence nor mechanical skill in any degree. These she would recommend to become or remain unskilled laborers. Then there is a group who have mechanical skill with relatively little intelligence. These should be advised to become skilled mechanics. A third group have intelligence with a minimum of skill. They should be clerical workers, or if their intelligence is sufficient should become lawyers, teachers, and investigators in the subjects like history and literature that require a minimum of manipulation. A fourth group has both high intelligence and mechanical skill. These would be foremen

where intelligence is not too great, and for the highest grades might enter the engineering profession, become dentists, physicians, especially surgeons, and scientists. Certainly mechanical skill seems a quality that is partly independent of intelligence. On the whole, however, the two tend to go together. While there are exceptions, the more intelligent are also on the whole the more skillful.

Differences in Emotional and Voluntary Qualities.— The emotional and voluntary qualities have not been investigated with anything like the completeness they deserve. One method uses personal estimates of these qualities in groups of individuals. One experiment of this kind was made by Webb. He asked masters to grade a group of boys with reference to a series of traits such as good temper, tendency to persist under difficulties, and similar qualities, and then tested their intelligence and compared all the estimates and tests with school grades. In general he concluded that any desirable trait whether intellectual, volitional, or emotional was likely to be possessed by the same individual, that an individual who stood high in any one of these respects was likely to stand high in all. This means that qualities as a whole are divided without compensations, that a man of low intelligence is not endowed with sufficient persistence to make up for it, but if he grades low in one he is likely to grade low in both and to have an unpleasant disposition as well. The exceptions in which a student of low intelligence can accomplish much by hard work and extra time would serve to prove the rule, or more truly is an exception which attracts attention just because it happens so infrequently.

Men, then, may be regarded as differing in four ways which stand out above all others: in intelligence, in mechanical skill, in amount of persistence, and in emotional balance or tone. The latter two are probably quite as important in their social relations, and even in contributing to the success of the individuals as are the first two, but measures of them are lacking as has been said, so we have little accurate information concerning them. The unbalanced will and the unbalanced emotional disposition contribute with the lack of intelligence to give us the criminal and the pathological cases which we call the insane and the neurotic. Possibly it will be better to leave what we have to say of these as individual differences to the chapter in which we discuss the occasions and means of prevention since the measurements which we do not have as yet are required for any study of their distribution.

QUESTIONS ON CHAPTER III

1. What can we mean by intelligence?
2. How is intelligence distributed in the population?
3. How can intelligence be measured?
4. Why are men inclined to think all men so nearly equal in intelligence?
5. Test fifty children of the same age by the army test. How do they stand in raw scores and in terms of A, B, C, D, and E classes?
6. How would intelligence be related to good temper? to initiative?
7. Is the boy or girl the more likely to stand high in intelligence?
8. Would there be any difference between rich and poor? between successful and unsuccessful? in trade or profession?
9. What effect does intelligence have on scholastic standing? Who are the repeaters?
10. Can the more gifted child finish the grades more quickly?

Would it be possible for him to skip without loss? At what age?

11. Suppose a child of ten should prove on test to have an I. Q. of 80, in what grade would you expect to find him? What would be the character of his work in that grade? A child of eight with an I. Q. of 120?

12. What percentage of the prison population are defective in intelligence? What percentage of the total population?

13. What professions or callings would be open to a man with an I. Q. of 140, provided he had motor ability? Provided he did not?

14. Suppose a man with an I. Q. of 140 lacked initiative, what would be his chances of success? What calling might be suggested?

REFERENCES FOR CHAPTER III

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CHAPTER IV

THE DETERMINATION OF INDIVIDUAL DIFFERENCES

The Causes of Differences between Individuals.—One question of general interest for theory if not for practice is what makes individuals different. Two answers have been given in recent times: the one school asserts that differences between individuals are altogether due to environment or to training; the other that they are due just as exclusively to heredity or descent. In general, students of heredity and of biometry argue that they are due to heredity, while the sociologists on the whole are inclined to give more if not exclusive credit to environment for making the individual what he is. One can, of course, hope to reach a conclusion where the difference of opinion is so great only by studying the evidence educed by each school as carefully as possible.

Similarities in Ability between Parent and Child.—The actual studies have been made by Galton, Thorndike, Wood, and Pearson. Galton in his volume "Hereditary Genius" worked statistically to show that great ability in any one line was likely to appear in several successive generations of the same family. He showed from the biographies of distinguished English jurists and scientists, as well as of musicians and artists, that the chances were greater that a son of a distinguished man would himself be distinguished than they were that a

son of a less distinguished or average man would reach distinction. These statistics are above reproach, but one might argue that it was due as much or more to the fact that the distinguished man guided the education of his sons, selected their friends, and even made a place for them within the charmed circle of the profession, as because he was their physical father.

Studies of Inheritance in Twins.—To answer this objection Galton, Thorndike, and recently Merriam undertook a study of twins to see what it was that made them similar in disposition and other mental qualities, or if they were similar in their qualities. Galton worked by less specific observation, by the opinion of individuals, as he worked before the days of mental measurements and the use of the statistical method of correlation. Both Thorndike and Galton, curious to say, were struck by differences between twins in these respects rather than by their similarities. They found that twins always showed very considerable differences. Instead then of trying to show from their similarities that they had the same heredities, that the same conditions controlled both in their intra-uterine, and earlier germ cell development or origin, they assume that their environment is exactly the same, since they live in the same house with the same mother and father and servants, go to the same school, are usually dressed alike and treated exactly alike in every way, and that the differences which they find them to show must be due to the hereditary forces. They vary because of the different influences which acted in the growth of the germ cells and later. One has no reason to question the existence of the differences that they find, but it seems that the whole con-

clusion rests not upon observed facts but upon the assumed premises that the environment is necessarily the same for two individuals who are reared from the same age in exactly the same surroundings, and then in referring the differences which are assumed, but which cannot be measured, to the hereditary prenatal influences.

One might with just as great plausibility assert that the environment is different and that the heredity is the same, and that the differences were really due to the environment. Certainly, if heredity could be the same in any two individuals, it would be expected to be in twins. This would be particularly true if they chanced to be identical twins, *i. e.*, individuals which result from a splitting into two parts of a single ovum, so that the two individuals develop from a single cell. On the other hand, what one sees of the rearing of children makes it very likely that the environment is never exactly the same for two children even when they are at the same time in the same house under the control of the same parents and servants. The mental attitude of the parent may be very different towards each. One may be favored at the expense of the other, particularly if of a very much pleasanter disposition. One may also be subjected to discipline that the other does not seem to need, and his reaction to that discipline may have a very definite effect in developing a habit of repetition on his part, and of suspicion as to his motives on the part of the parent that will make his environment emotionally very different from the environment of the other. This should not affect what we call innate ability, but it might very well determine the persistence of the child in tasks, particularly if one child should chance to be

regarded as incapable and so relieved from tasks that the other was compelled to do.

The assumption that it is the environment that accounts for the difference is the more plausible in view of the fact that the older the twins the less alike they are. Merriam found that the coefficient of correlation in different intelligence tests ranged from .965 to .519 for twins between the ages of five and nine years, while it dropped to a range from .919 to .072 for twins between nine and sixteen years. It was less in all but two cases for the older twins, and then the difference was but slight.

Conclusion the Same on Either Assumption.—Curiously enough one can draw the same conclusion from either set of premises. If we assume that they are born alike and are made different by the environment, we must admit that at sixteen they are still much more alike than brother and sister although there is no reason to believe that the environment is appreciably more similar. If we make the assumption of Thorndike and Galton that the differences which appear later are the result of the development of latent tendencies to grow apart that appear in spite of the similar education and culture, these hereditary forces to change persist in spite of the environmental forces.

On the whole, then, these studies are fairly conclusive that most is due to heredity. The degree of similarity which Thorndike found to run from an r of .50 to nearly complete identity, with a central value of about .75 or .80 as compared with .50 for children of the same parents, not twins, would be due to heredity, even if one were content to ascribe the differences noted in part to environment as well as to heredity.

Importance of Heredity Evident from Similarities of Brothers.—Another measure of heredity of mental traits in children was conducted by a direct method, using the teacher's estimates of ability in various respects as the measure of the similarities to be correlated. This study was undertaken by Karl Pearson in 1902. He asked teachers in several parts of England to grade the brothers and sisters in their schools with reference to a number of mental and moral traits, including success in school subjects, their general intelligence and disposition. In summarizing the results, he finds that the coefficient of correlation of the brothers and sisters for different mental traits is almost as close as he found it to be for the physical traits. In other words, one is just as likely to inherit the disposition of a parent as the length of his forearm or the color of his hair or eyes, or any of his physical characteristics. All have an r between .40 and .50. So confident was Pearson that the mental qualities were inherited that he argued that the national good demanded that the intellectually best be encouraged to have more children, and that education be neglected or at least subordinated to that end. He asserted, what is probably true, that one can never produce intelligence by education, that one must begin much farther back in actually insuring the birth of intelligent people. Education may enable one to make use of intelligence; it certainly can never create it.

Environment Ineffective as Compared with Heredity in Effect on Intelligence Tests.—Comparison of the results of measuring the intelligence of school children by the Binet and other tests also has led most authorities to the same conclusion, although the con-

clusion rests in part upon the assumption of the premises deduced from the facts that we have already mentioned. When the intelligence of children that come from good neighborhoods is compared with that of those that come from the poorer neighborhoods, the children of the better neighborhoods all have the advantage. Comparisons have been made in Oxford between the children from the private schools, and those from the board schools. The children of the one were those of the officials of the church, professors in the universities, and similar men of distinction, for the most part, while the children in the board schools were those whose parents were small tradespeople, servants in the university, and similar members of the lower middle class. It was found that the intelligence of the former was distinctly better than that of the latter in whatever way it was measured.

A similar test in a California university town showed the same difference in about the same degree. In other places where the comparison has been made on the basis of schools in different parts of the city, one inhabited for the most part by people of larger incomes, and the other by people of smaller incomes, it was found again that the intelligence of the more well-to-do children was higher than that of the poorer. One might explain all of these results as due to the better environment, better nourishment, and greater leisure of the children whose parents were higher in the social and economic scale. In the light of the preceding studies it seems more probable, however, that the difference is due to the inheritance of the greater intelligence which enabled the parent to attain a better place. This

is reinforced by studies of a few cases in which the families have once been prosperous, but have been compelled through misfortune, the death of the father, or long illness to move to the poorer neighborhoods. In these instances the environment would be the environment of the lower classes, the heredity that of the higher. Here the hereditary factor dominates and the intelligence of the child corresponds to the intelligence of the parent rather than to that of the neighbors in the same environment.

Feeble-Mindedness Follows Mendelian Laws.—More direct in its bearing, possibly most direct for the inheritance of intellectual qualities of any of the studies, is that which has been made upon the inheritance of mental defects. Goddard studied hundreds of cases of inmates of the institution for the feeble-minded in New Jersey. He had field workers investigate the family history of each case and determine the intelligence of all of the ancestors that could be found. The results when tabulated showed that feeble-mindedness in all forms except those that were due to definite bodily injuries or to disease was inherited. The statistics proved that it was a unit character of the recessive type, in terms of the Mendelian hypothesis or law. It followed the Mendelian law as completely and accurately as does the inheritance of color or size in the animals, or the inheritance of different qualities in plants. If a normal individual marries an abnormal, that is, a feeble-minded one, the children will all be normal. Certain of them will have a latent capacity for producing feeble-minded children, provided one of them marries a feeble-minded individual. Where a feeble-minded individual marries an in-

dividual who has this latent character, one of the children will be normal, one feeble-minded, and two will be normal but with the latent possibility of producing feeble-minded progeny. Where both parents are feeble-minded all the children will be feeble-minded. The great danger for society comes from the marriage of individuals themselves normal but with the latent disposition to produce feeble-minded offspring. For a complete proof nothing is lacking to show that feeble-mindedness is inherited, and that training or environment can do nothing to eradicate it when present, and also, aside from accidents to the head or infections of the nervous system, can do nothing to produce it in normal individuals. It is a matter that can be cured only by preventing the mating of the feeble-minded and those who contain within themselves the seeds of feeble-mindedness even if those be latent.

Summary of Evidence for Heredity.—As a matter of evidence, then, we have the certainty that low orders of intelligence are inherited; we have great probability that many of the characteristics of the normal individual are determined by the specific inheritance. Here we are less certain how much and what is due to heredity and what to environment and training. In general, it is safe to ascribe most of the capacity to heredity, and to regard the specific form which that ability is to take as partly due to heredity and partly to training and the suggestions of other men. Man is born to great or little capacity in any line. Whether a man is born to be a poet rather than a scientist, or whether that decision is made by the men who teach him or give him his ideals we are not as yet prepared to state. A man may, so far as we know yet, be born with the capacity that

would make him either a great engineer or a great historian, and whether he becomes an engineer depends upon whether he is brought into contact with other engineers, becomes impressed by the greatness of their calling, and also has a chance to learn the profession and to discover that he can succeed in that line. How far abilities are specialized in heredity and how far a good man in one line might have been equally great in another, provided he had only had occasion or opportunity, much more data is needed to determine.

From the standpoint of the teacher, it is essential for the community that he recognize early the individuals of great ability, and so far as possible determine what particular sort of ability it is, and then do everything possible to encourage that individual to make the most of himself in the line for which he is best fitted or in the one which seems most to be needed in the society of the time. This is the more important since there is a tendency for the best lines to become infertile when they reach a moderate stage of comfort. The social and other demands upon the wife, the desire to maintain a standard a little better than they have or than that to which they have been accustomed tends to limit the size of the family so that the best are always too few to perform the functions which are essential to the life of the society. On the other hand, the feebly endowed lack all foresight, they have no standards, and so far as they do think, regard children as an aid rather than a hindrance. In consequence, their progeny will always increase in numbers very rapidly. When by chance a child of superior ability appears in a family of less ability, it is a social duty to see that he be given a chance to

show what he can do, and not be wasted on the unimportant tasks of life.

QUESTIONS ON CHAPTER IV

1. What determines the intelligence of an individual? Can it be changed by Education?
2. Give evidence that intelligence is inherited.
3. If an intelligent man married a feeble-minded woman, what would be the intelligence of the children?
4. Assume a woman with an I. Q. of 140 marry a man with an I. Q. of 130, what would be the intelligence of the children? Suppose six to be born; state the center or median I. Q. and the range? Suppose the I. Q. be 130 and 70 respectively, what are the probabilities?
5. What relation between the number of superior children in a well-to-do neighborhood and in the slums? Is the difference due to education, nourishment, and environment in general, or to heredity?
6. What is the relation between financial success and intelligence? between intelligence and happiness or contentment?
7. What is the coefficient of correlation between I. Q. and the strength of will or initiative according to Webb?

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CHAPTER V

THE GENERAL CHARACTERISTICS OF MAN

Determination of Reflexes.—In the last chapter we discussed the dependence of the individual upon his particular heredity. Descent in the more general evolutionary sense must also be taken into consideration in the original nature of the child. The child when he comes into the world may be regarded as a bundle of reflexes and instincts. The reflexes are relatively slight and simple movements that serve to remove the disagreeable stimuli that affect an individual sense organ and also include simple beneficial movements. Instincts, on the other hand, are complexes of movements that serve either to remove harmful or to enable the individual to take advantage of beneficial conditions that are presented to the organism, or to enable the organism to deal with wider situations. A reflex is best typified by the drawing back of the hand when burned or bitten. This the physiologist assures us is due merely to the effect of the severe sensory excitation, which produces a nerve impulse strong enough to pass through two or more units or neurones along the bridge of protoplasm that constitutes the nervous system. The chemical process which is aroused by the sensory excitation results in the stimulation of the other chemical process that contracts the muscles. This it is which withdraws the hand from the source of stimulation. Sneezing, swallowing when

food is put into the mouth, winking, and all such simple responses would fall under the head of reflexes.

Instincts and Reflexes.—Instincts are slightly more complicated, although they too must find an explanation in the passage of chemical reactions through the nervous system. As a matter of mere classification, it is not easy to say when a movement is reflex and when it is instinctive. The crying of a child would probably be classed as instinct. Here the stimulus is usually not directly applied to the sense organ in the reacting member nor to any part that is closely connected with it. It is aroused by the absence of parents or other persons habitually about, by pain in any part of the body, or by other remote stimuli. The connection that produces the excitation is less easily understood from mere mechanical or chemical processes, in spite of the fact that the movement is made possible by chemical reactions and is determined in its course by connections which have been at some time established in the nervous system. All movements which we regard as essential to the survival of the individual or to the continuance of the species, but which are not closely enough determined by mechanical conditions to be called reflexes, we class as instincts. As will be seen from this discussion, the line between instinct and reflex cannot be sharply drawn. In practice what one man calls instinct another will call reflex, and some have gone so far as to insist that all is reflex.

Instinct Determines Human Goals.—For our present purpose it is important to insist that the child comes into the world with a number of tendencies to movement and actual movements that are not the result of training in

any sense, and that these determine in the broad outlines many of the activities which must be taken into account in his education. So far as it is possible to do so and attain the ends of education we must work with the instincts and not against them. In many cases, we could do nothing to change the instincts if we tried and where we can change them it is frequently only by appealing to other instincts which favor what we are striving to accomplish. Instincts in this sense guide and set a limit to the efforts of education.

Origin of Instincts.—An understanding of instincts requires a brief statement of the way in which they may have been supposed to originate, of the classes into which they may be put, and of the relations which they hold to other mental or physical operations. Instincts are the results of the inheritance of changes which the organism has undergone. They originated by chance and persist because they make the organism more likely to survive or to survive in greater numbers than were the other members of the race or species. Biology insists that all living things are determined in their activities by the stimuli that work upon them and by the character of the nervous system upon which those stimuli work. The essential factor in the nervous system is the connection or set of connections that are established between element and element and thus make possible the transfer of impulses from one to another, and so from one part to another of the bodily mechanism. If a given stimulus affects one part of the skin and the part is connected by these open paths in the nervous system with one muscle, that muscle will contract and the corresponding movement will be made. If it is connected with another

muscle that muscle will contract and another movement will result. What determines, then, whether one movement or another will be made upon any stimulation or upon the stimulation of any one part of a sense organ, is the connection in the nervous system between that part and the muscles of the body.

The Origin of Instinct through Selection of Chance Changes.—The problem of instinct is to determine how these particular sense organs chance to be connected with these muscles. The answer originally must go back to the unknown factors in the evolutionary forces that work upon the individual. The biologist now insists that the environment does not directly produce any change in the organism, all it does is to select those organisms or those changes in organisms which happen to develop as a result of the at present unknown changes that take place in the individual in the course of development. If it chanced that an organism was provided with a nervous system that drove him to acts that were dangerous—that led to his destruction—he would be killed; none of his kind would survive. If, on the contrary, as holds for the most part, the acts that his nervous system compels him to make serve the needs of the organism, he will survive. The evolution of instincts must have been closely connected with the evolution of the organism. If we assume that any individual should change in such a way, that the movements ordinarily made to a given stimulus are improved, become more suitable and the change should be transmitted, the descendants of that individual would survive in greater numbers and in consequence that movement would be established in the descendants as an instinct. This may well have happened

to the first moth that was stimulated by the odor of the yucca plant to lay its eggs in the seed pod and then to place pollen in the pod with them. As that movement proved beneficial, the progeny survived and inherited the tendency. If any member of the species had chanced to develop a tendency to lay the eggs in a place where they would have been destroyed, the eggs would not have hatched, the tendency would have become extinct with that individual, and so no instinct would have appeared.

Instincts due to Chance Changes in the Germ Cell.—Instincts are believed to take place purely and simply because the germ cells undergo changes which establish new connections in the nervous system of the animals that develop from them and so compel them to make movements of a new kind. When the movements that result are beneficial to the organism, it will flourish, will live longer and have more offspring. When the movements are of the opposite character and result in the death of the animal or increase the chances of death, or reduce in any way the number of offspring, they will obviously decrease the number of individuals who will be capable of those movements, and in consequence the movements will be automatically made to disappear or prevented from becoming established.

Instincts Persist through Survival of Organism that Develops Them.—Metaphorically one may think of instincts as the result of a process of trial and error on the part of Nature, or of the physical causes that really constitute Nature. When the combination of internal conditions upon which inheritance depends chances to give rise to an organism with a nervous system of a type to make it respond in a way suited to its environment,

it will live. When the responses that it must make bring it into serious conflict with its environment, it will die. In this way one may picture life as the reward of chancing to develop a nervous system that shall give rise to suitable instinctive responses to the environment in which the individual lives, and death as the punishment for developing a nervous system that makes necessary instinctive responses seriously unsuited to the environment. We need not consider the justice of rewarding or punishing for the outcome of conditions that cannot be helped, for ours is only a metaphor. Suffice it to indicate that as a result of the myriad chances of chemical combinations, and the long continued action of selection, we find the members of the present generation armed with a set of instinctive tendencies that adjust them reasonably well to the environment in which they live.

The Classification of Instincts.—For convenience in discussion it is necessary to group instincts into classes. The most convenient is in terms of the ends that the instincts subserve. Obviously instincts must have developed that shall care for the great common needs of the individual and of the species. The great needs are first that the individuals should be preserved and continue in the greatest numbers, then that the race should be continued, and third that the social group to which the individual belongs should be protected and improved. We class as individual those instincts that make for the good of the individual, prevent him from being injured, and supply him with the essentials of his existence. Avoiding dangers, seeking food, etc., fall in the class of individual instincts. Into the class of racial, fall the

tendencies which make it necessary or agreeable to perform the acts essential to the propagation of the race. The social instincts are those that compel the individual to act for the good of society and for other individuals who belong to the social group. Obviously these groups are in many ways interdependent. Neither the race nor society could survive if the individual were destroyed. On the other hand, the survival of the family and of society may further the survival and the prosperity of the individual. The different groups also shade over into each other so gradually that it is not always possible to say into which class a given instinct may fall. On the whole, however, the classification is convenient and presents as few logical objections as any.

Primary and Secondary Instincts.—Before we can discuss the details of the classification, it is essential to distinguish a still more fundamental difference between instincts. As was said in the early part of the chapter instincts are usually defined as movements which are made because of inherited connections in the nervous system. Certain instincts belong in this group. The movements of eating or of crying are instincts in this sense. In a much larger group, however, what is instinctive is the feeling that attaches to the anticipated or actually realized end. These usually result in or lead to movements, but the movements are at first only tentative, they are not fixed from the beginning as are the acts of the first group. Most of our human actions are instinctive only in this last sense. The end is pleasant because of our innate character, but the way in which that end shall be attained is learned.

The difference between them can be well illustrated

by Lloyd Morgan's description of the pecking and eating of a moor chick that he watched. It pecked at every small object indiscriminately. This is a primary instinct, as the movement is elicited by the sight of the small object. When, however, the object had a bitter or other disagreeable taste when it entered the mouth, it was ejected; when it had an agreeable taste, the act of swallowing was completed. Here, what was instinctive was the pleasure or displeasure, which stood as a guard over the stomach just as truly as would an instinctive reaction. In this case, too, the act that resulted was one and immediate. In man when the end is pleasant, discomfort persists as long as the end, contemplated or imagined, is delayed, but the way of attainment is only to be learned by trial. Secondary instincts, then, are instinctive only in the pleasure that comes when the end is attained, or in the dissatisfaction that attaches to dangerous stimuli, or to the absence of pleasant stimuli. In this case chance movements are evoked which continue until pleasure is obtained. These, however, finally compel the individual to attain the end as surely as, if more slowly than, would a group of inherited simple movements.

When we ask, then, how many instincts we find in man, we must be careful to distinguish the primary and secondary. If we mean primary, there are very few, so few that some men have insisted that there are none. If we include the secondary, man has many, in fact, all of the real ends of man are prescribed by instinct, and the final cause of most of his acts and of his thought is instinctive. We must keep the two meanings of the term in mind in all of our discussions.

Primary Instincts.—Recent careful studies by Watson of the instincts of young babes from birth to the 200th day or more show but very few simple responses that are universal. One of these is the grasping instinct. The hand of the new-born child closes immediately upon any object that may be clasped by it, and the grasp is sufficiently strong to support his weight, almost enough to support the weight with either hand alone. This movement was regarded by Darwin as evidence of the descent of man from a tree-dwelling animal, for if an instinct of this type should be lacking in an animal born in a tree, it could not, in a large number of cases, survive its birth. A second instinct he noticed in all the children was a tendency to handle all objects that came near. This is also of value to the human infant in compelling it to investigate the different objects in the world about. Out of it develops the instinct for manipulation which Watson also found to be universal in the young child. Swimming movements, which had been reported by certain observers, were found not to be instinctive. Very few fears were exhibited by very young children. There was fear of falling, but none of strange animals or noises, no dislike of dirt as represented by sticky paste smeared on the hands. In short, aside from crying, the instincts involved in taking food and those mentioned above, instincts were almost altogether lacking in the numerous children studied by Watson, a number sufficiently large to be representative.

Connate and Delayed Instincts.—This again requires a distinction in the way of definition. Not all, even of the primary instincts, need be present at birth. Some undoubtedly develop later as a result of the ripening of

the nervous system. Thus, one can frequently observe the advent of fear in a child without any transfer from another object and without any particular new occasion in the stimulus. A child will have enjoyed playing with fur, and then if the fur be not seen for a time even if no animal or other furry object has injured or startled the child, there will suddenly be a drawing back, a shudder, even tears when fur touches the skin. We can explain this and similar responses only on the assumption that there is a stage in the development of the nervous system when the fear reaction to fur appears as the result of the development of new nervous connections. Many instincts, including notably almost the entire group of racial instincts, are thus delayed.

We cannot assume that Watson has exhausted the entire list of human instincts, although we are quite willing to grant the exhaustiveness of his study of the first two hundred days of the infant's life. Many of the human instincts may very well appear first considerably later than the period covered by his study. While it is more difficult to study these instincts of later development because they are much mixed with habit, and it should be said in fairness that few studies comparable with Watson's have been made of this period, observation indicates that there are many activities of instinctive origin that must be considered. A complete list cannot be given because of lack of data, and the lists that are given do not agree in all respects. We shall notice, too, that most of the instincts that are mentioned in the later periods fall in our second class of the instincts determined only by the end desired rather than as immediate movements.

Instincts in Education.—Of the individual instincts that are important in the education of the child, we may mention curiosity, construction, or constructiveness, pugnacity, to select from a well-known list. Of these curiosity might be regarded as fundamental in all education. It impels to knowledge in the early explorations of the child and is, on the broader scale of scientific investigation, the driving force in the acquisition of most learning and in many scientific researches. Anything that cannot be given a place in past experience is unpleasant and a challenge to investigation, while finding an explanation for each of the unknown objects or unexplained events gives keen satisfaction. There is obviously no single movement or group of movements that can satisfy curiosity. The instinct is really only the unpleasant feeling that persists until the unknown is understood, and the pleasure that follows satisfactory disposal of the object or event.

Constructiveness.—Constructiveness, which is given a place as an individual instinct in most lists, is equally important in life and in the more motor phases of education. It consists of two parts, one, developed from the primitive instinct of manipulation which Watson observed in the infant, impels to constant handling of any object and may result in producing desirable changes. The other fact, more akin to curiosity and involving something of pride in achievement, with its implication of self-approval, is to be recognized as delight in workmanship. Between them they are responsible for the delight in whittling or building with blocks of the small boy, as well as for driving the inventor to his designs. It is also an element in keeping the skilled workman to

his task or his trade when others requiring less skill are better remunerated. As a factor in impelling to neatness, and in satisfying with manual training boys who do not succeed in the regular subjects, it is an important incentive in school work. It, too, is not a movement or a complex of movements made to a particular stimulus, but a group of feelings that give pleasure when a given end is attained, and produces a restlessness or discomfort until it is reached.

Collecting.—Much the same may be said of collecting and pugnacity. In the squirrel and certain of the other lower animals, collecting seems to be an instinct of the first class in which the movements are determined by the stimulus and the connections in the nervous system. The nut when the squirrel is sated calls out the burying movements whatever the conditions. Even when the squirrel is given a nut in the house where the burying movements are without value, they are run through in the same way and the nut left in full sight on the rug after they are completed. In man each act of collecting requires a different group of movements, varying from carrying bills and a book to a bank, to stooping and putting the hand in the pocket. The end is pleasant if in varying degrees, and that alone is the justification for calling collecting an instinct. The feeling of elation is the same whether the treasures consist of a pile of bonds in the safe, the cans of fruit in the cellar, or the accumulation in a small boy's pocket.

Pugnacity.—Pugnacity is also a tendency which finds expression in different movements. Some of these, as striking with the fist, may be movements determined by the muscular and nervous organization, but the end of

overcoming the antagonist may be attained as satisfactorily and more thoroughly by various weapons, or by business manipulations. On the whole, it is the pleasure that accompanies the end or the displeasure that persists until the end is attained that justifies calling pugnacity an instinct.

Probably no list of the individual instincts is altogether complete, and it is very difficult to arrange them in the order of importance. These with the instincts of infancy may be regarded as typical. Suffice it for us to add that all of the essential needs of the individuals are outlined in his instincts. He is compelled to satisfy them either by the fact that he must make the appropriate movement when a stimulus is given, or he is driven to experiment with his possible movements until he satisfies his needs, by the displeasure or restlessness that persists until they are satisfied, or the pleasure that results from satisfying them.

Racial Instincts.—The racial instincts are equally impelling, sometimes even stronger than the individual instincts. The classes may be a little more sharply drawn. They refer to the three primary functions of mating, the care of the offspring, and the reciprocal response between the children and the parents, although this reaction is probably less assured and less certainly instinctive than the others. The mating instincts are evidenced in the activities of courtship. These, it is evident, are not prescribed in man as they are in the animals. The selection of the mate is forced on both sides by instinct. Still one cannot assert that one type of man and one type of woman have a particular affection for each other, although the romantic novelists

imply some such specialization of instinct on the part of both. During the period of courtship there is a certain amount of showing off as in the animals, brighter and more attractive colors are adopted, or at least more care is taken with the dress on both sides, but the adornment adjusts itself to the prevailing styles. There is a specific bashfulness or incoherence in response on the part of the male in the presence of the girl, and a corresponding coyness on the part of the girl. These cannot be avoided although it is difficult to see how they forward the purposes of Nature. But all other acts adjust themselves to the conditions and fashions of the moment. The automobile replaces the carriage as a means of wooing with no perceptible difference in the final effect, and no perceptible difference in the feelings.

Parental Instincts.—The care of the child is again prescribed only roughly. The essential characteristics of the act of nursing must be preserved, but the other elements of the care vary with tradition and with change in styles. The mother is distressed when the child cries and is, unless warned by the physician or nurse, led to do many unwise things to prevent the outcry. The process of caring for the child would, without scientific knowledge, be one of trial and error with the amount of outcry on the part of the child as the only guide to success. Similarly, the satisfaction at the sight and feeling of the child impels the mother to remain in its presence as the pleasure from nursing would probably impel to that act, not necessarily wisely as to time or amount as measured by the results of pediatrics. All of these acts belong more truly to the secondary than to the primary instincts. The end to which the instincts impel is at-

tained more certainly by the rules of the child specialist than by compliance with the immediate instinctive tendencies. Much the same may be said of the instinctive care and respect for the parents on the part of the children. This belongs almost entirely in the secondary group, the only guide is the pleasure of the child in response to the pleasure or comfort of the parents, or his discomfort when they suffer.

The Social Instincts—The social instincts require a slightly more detailed treatment as they are not quite so obvious and as they are more important in the function of the teacher. At first thought, the presence of social instincts might even be questioned. It seems that Nature could hardly have required the coöperation or grouping of men sufficiently to have endowed them with instincts that should bring them together. That might be true were man and species of the other feebler animals capable of existence in isolation. As it is, man and certain of the animals seem not to be capable of continued existence in the presence of other animals and of certain physical dangers except by mutual coöperation. Certainly coöperation makes for a greater efficiency and so for the survival of the individuals in greater numbers and in larger proportions. If, again, one personify Nature, it seems that she is interested only in the survival of the mass, not of the individual. The instincts are adjusted to produce the largest race, the largest group, and when a few individuals must be sacrificed to the survival of the many, instinct provides the incentive.

Gregariousness—The first of the social instincts is gregariousness, the instinct which makes sure that indi-

viduals shall be brought together and remain together to constitute the group. On the feeling side, a man is happy only in the company of others. As Galton has said, a man may pay no attention to others when with them, but still desire to go to the city that he may see others of his kind and feel their presence. Deprivation of human society for a long time produces acute discomfort. This is evident in the attitude of the lonely shepherd to the passing stranger and also in the torture that is inflicted by solitary confinement. This instinct brings the scattered elements of a tribe together and holds them together when they are once gathered.

Sympathy.—A second more positive social instinct is sympathy. This asserts itself by making any individual suffer at sight of the suffering of others and less certainly makes him rejoice at the pleasure of another. As a social force it is effective in compelling the one to relieve the suffering of another. One must suffer so long as the other suffers; even if one moves away or closes the eyes, the memory produces pain, and this persists until relief is given to the other. The result is charity, and mutual helpfulness.

Social Pressure.—A third group of social instincts is effective in social discipline, in repressing the activity of each member of society, or at least in making it subordinate to the desires and will of the group as a whole. The first effect of this is seen in bashfulness, which often almost amounts to fear of the group as a whole. One who is not accustomed to appearing in public feels positive discomfort in standing up in front of an audience, and one who is accustomed to appearing before a group in one place may be struck with the

emotion, and so disturbed that he can hardly express himself when before an unfamiliar audience or before a familiar one in a new place or situation. The discomfort attains almost to physical pain with curious twitchings and changes in circulation that are altogether unreasonable when thought of from the amount or lack of physical danger that may be present. This seems to be the fundamental type of the instinct.

In a slightly modified form it is found in pain at the disapprobation of a group. In this form it is essential in the development of social discipline. One sees it clearly in the crowd when a man will let pass unreproved or even will accept statements or remarks that would be challenged when alone or even when in a small group. There is an actual fear of man in the mass when physically present and this is carried over to respect for the opinion of society as a whole when not immediately present. Out of this grows the possibility of all social discipline. One is uncomfortable when one knows that one is doing what is not approved and one's keenest emotions of pleasure are connected with recognition from the group or from that part of the group that one respects. The pleasure of the child in a good mark lies largely in the feeling that it will bring the approval of his teachers or of his fellow students. The punishment of any one, child or adult, consists very largely in the same socially conditioned emotion. Were it not for this social effect, life in a prison might be more comfortable than earning one's living, and a child might very well count the pleasure derived from the infraction of a rule against the pain derived from the punishment inflicted on account of it.

Punishment and Social Disapproval.—When the child does not respond to these social forces, punishment is difficult if not impossible. This happens when the child or man no longer accepts the society which enforces the discipline as his group. For after all the social response is restricted largely to the group of which one counts oneself a member. Disapproval by a man outside of the group counts for very little. One does not care if the enemy thinks you are cruel, and one does not feel much elation if a man of a sphere that one does not consider of as high a social position as one's own approves of his manners. We all tend to group ourselves in different social classes, and each is impelled to action by consideration of what the particular group to which he considers that he belongs thinks. In schools these groups are constantly being formed. If the child thinks that he belongs to a different group from the teacher, the teacher's opinion counts for little. When this break in the feeling of social solidarity in a school or society begins, not much can be done in the way of discipline until unity is reëstablished. It is possible for a school to believe and practice that there is glory to be gained in receiving punishment from an unpopular teacher. Once that happens, no amount of punishment will reëstablish discipline.

Social Approval as a Means of School Discipline.—The forces of social approval and disapproval are the basis of most of control in the wider society as in the schoolroom. The power of the styles depends upon it. To the woman who pretends to be in society, and what woman does not? wearing a garment that is out of style to church or in a public place causes more discomfort

than an aching tooth, certainly more than freezing legs, as the styles at the present writing testify. The moral forces are almost altogether to be referred to the same instinct. Moral laws hold only for the individual who belongs to the group in which they are accepted. When a man deliberately removes himself from community with or acceptance by the group, the moral laws cease to influence him. This it is to become a criminal. Similarly most of the ends that a man regards as worth striving for are such as are accepted and esteemed by the social group. Money and the things that it buys are worth while largely because they satisfy the instinct of this social type. What one enjoys most in a fine house or in being a substantial citizen is the approval of the group that goes with it and is the outcome of it. It would not be worth while to have a million dollars or the physical comforts that a million would buy if one were the only individual alive. In every respect, what keeps society in being and controls most of the actions of the individual is the instinctive pleasure in social approval and the instinctive dislike of social disapproval.

For the student, the main incentive to going to school is to win the approval of the family and the group. The desire to excel in a profession rather than in a trade, the desire for wealth depends upon this same instinct. Even the desire for knowledge itself has a large social element. Social approval must be used and is used unconsciously in every appeal that is made to the student. Of course it is appealed to not as an instinct but as a duty, as a pleasure to be obtained by persistence. Even when the appeal is not explicitly of duty or to the social whole in so many words, it is that which is really effect-

ive, which gives the impelling force that makes the child do what is expected of him. Probably the less explicit all of these appeals are made, the more effective they are. If the child should be told that he had in him an instinct that compelled him to submit to the desires and the ideals of society and that he would never be happy unless he did so submit, he would be much less impressed than he would if told, as he is now, that he is expected to do what he does do under penalty of a bad conscience or because it will please his father. However, were there no such instinct, these appeals would be ineffective.

The Mutual Interaction of Instincts.—In general, the various types of instinct interact. All may be in conflict and at times several may lead to the same act or end. The individual and the racial come into opposition when the mother must decide whether to rest or care for her child, or when the father must decide if there is a famine whether to take food for himself or give it to his family. The racial and the individual are both constantly in conflict with the social. When a girl chooses between a new coat and a good meal, the social would impel to buy the coat, the individual for the food. Good sense must decide. In most matters of daily life the conflict, where decision is to be made, is between the social and one of the others. The social stand for the ideal ends, the right, duty, distant pleasures, as opposed to the sensuous joys. The fitness of the individual for the higher things is measured by the strength of this social instinct, although not all of the courses of action in harmony with the individual instincts are unworthy nor are all the courses enforced by the social worthy. In general the pleasures that we call higher correspond

to the social instincts, and those which we call lower correspond to the racial and individual instincts. In either case the impelling force behind most courses of action is to be found in instinct. If we ask why an individual does anything that he does from choosing food to going to bed at night, from seeking a fortune to going to school, the final answer must be given in terms of instinct of one type or another.

Habit and Instinct.—Instincts, however, are modified by habits and by other accquired responses and knowledge. One learns to discontinue instinctive acts that result in pain and to adopt or repeat and extend acts that result in pleasure. One might say that this again was in the last analysis instinct since the pleasure or pain that is excited by the act is of instinctive origin. This, however, is putting the emphasis upon the final occasion rather than upon the immediate method of responding. What is at first done at once as a result of some instinct that is probably not exactly fitted to the present environment, may be repressed by the present pain, or may, even if pleasant, be repressed because it meets with social disapproval. In other cases one finds that acts which seem at first to have no instinctive basis and to be indifferent so far as the feelings they arouse are concerned, may become established as habits and be repeated whenever the suitable occasion arises. Thus the instinctive tendency to peck at all small objects was quickly repressed in the young moor fowl by the experience with a bitter worm.

Habit Replaces Instinct.—In the child in school, acts that are at first due to the effects of social pressure alone may, through repetition, become matters of habit and

be done without thinking. Practically, everything that is a matter of manners is thus established by habit, by mere repetition. The manner of speech to the teacher, closing or opening the door, taking off the hat, refraining from whispering, is at first to be acquired through social pressure, and then when once acquired is repeated through habit. The more that can be reduced to habit the better. So frequently do habit and instinct overlap that it is usually difficult to say what is habit and what instinct in the older child or adult. An act that is first done through instinct and gives a desirable result will be repeated to constitute a habit. Their interaction is also evident from the frequent cases in which an instinct is repressed by habit. Fear of the dark or fear of high places disappears when one is frequently on a high place or has frequent occasion to go into the dark. Most instincts may be repressed by habit, and most are modified in some degree by habit before the child reaches adult life. The ideal of training is to make all desirable modifications habitual. Then they are done without conflict and without exciting undue emotion.

Play as an Instinct.—Two instincts that are especially important in the life of the child, or to speak more properly, two activities which are frequently called instincts may take a moment's discussion; these are play and imitation. We are told that it is an instinct to play. Certainly play is a constant activity of the child and one that requires much attention on the part of the teacher. But play is probably to be regarded as the expression of the fact that a child is constantly in action on the one hand, and that this activity is constantly being drained off into instinctive channels on the other. A child is

never quiet because he is constantly being stimulated through his senses and these stimulations must lead over into motor responses. The nature of each motor response may be said to be determined by instinct as are all other responses. In this sense play is not one instinct but many. The actual plays are also much dependent upon habit. The character of the games depends largely upon the plays that have been learned and so upon the individuals with whom one has been thrown into contact. In some degree the plays are a practice of acts that will be valuable in later life. There is some specialization in the sexes. The girl on the whole indulges in games which are a part of the duties she is to have in adult life, plays with dolls and at keeping house, while the boy deals with games of the chase and of conflict. Even this specialization is as much a matter of tradition and of what is expected of the girl in society as it is of instinct. On the whole, then, play is not one instinct but many, and it is, like all other acts, partly instinctive and partly habitual.

Instinctive Elements in Imitation.—Imitation, too, is partly instinctive, but more a matter of the control of action by ideas. Obviously, it is not a primary instinct in which the movement is definitely prescribed by the sensori-motor connections, for we imitate all sorts of movements. All that one can say is that there is a tendency for the individual to make any movement he sees or appreciates through any of his senses. The thought of an act serves in some degree to make the individual repeat it. That means that the individual is likely to imitate. This is not an instinct but merely one expression of what has sometimes been called the law

of ideo-motor action. In addition there is sometimes pleasure in doing what one sees or hears another do. This is seen very clearly in the way a child learns to speak. He repeats the sounds he hears because they are interesting. When he is first learning a sound, however, he must learn by trial and error. It is only when he chances to hit upon a sound in the course of experimentation that he repeats it, and then it seems probable that he repeats only because having heard the sound it is interesting to him. Tests on animals and men show that neither is more likely to make the movement the first time because he has seen it made.

Summary.—In education, instincts must be taken into account in two ways. In the first place, it is much easier to teach a child if one considers his natural aptitudes. He will attend readily to things that have an instinctive interest for him, and he will do easily the acts that correspond to his instincts. Where it is possible to take advantage of his instincts, it makes learning easier and the acts are performed more effectively and more willingly. The second and more important way in which instincts may be made use of lies in appealing to the ideals of the social group to which the student belongs for inciting him to accomplish tasks which are not instinctively pleasant, but which must be performed if he is to attain the ends essential to his own good and to the welfare of the group. To the ideals of the home, of the school, of the smaller civic groups, and of the nation, the child responds because of the pleasure from approval and the unpleasantness of the disapproval of the group. The attainment of these ideals demands frequently the study of particular subjects or lessons that

are not instinctively pleasant. The respect for the social group forces the student to attain its ends whether he likes to or not. Instinct of the individual type should not be permitted to determine what shall be taught, but may very well be taken into consideration in determining the way it may be taught.

QUESTIONS ON CHAPTER V

1. Name ten instincts that you observed in a child in the course of an hour.
2. How could an instinct of trembling from fear originate?
3. How might an instinct of readiness to self-sacrifice arise and survive? Would self-sacrifice itself survive?
4. What of ten child's instincts may be made incentives to education?
5. What instincts determine what may be taught and which can be used to urge to any desired end?
6. How far are the instincts in play primary and how far secondary?
7. How can instinct determine what habit shall develop?
8. How does instinct shade over into learning?
9. How distinguish between a delayed instinct and a habit? Give illustration of each.

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CHAPTER VI

THE ENDS OF EDUCATION, THE LIMITS IN ATTAINING ITS END

Education is First Acquiring Facts.—Before we can go far in asking about the means or methods of education it is necessary to decide what the purpose of education should be and how far we can expect to attain its ends. We can say in popular terms that education is expected to give the individual who is submitted to the process a certain amount of knowledge, the knowledge and specific skill that is required for earning a living and for maintaining himself in the station that his parents have attained. This training may be either specific or general. The school system as a whole can be expected to give the general knowledge required by everyone to take an intelligent interest in the social and economic activities of the community and of the nation. It may also be looked to to give the general skill and knowledge required for all occupations. Everyone needs to know how to read, to know something of the history of his country and of the world in general, to know other languages than his own that he may appreciate other points of view, to be able to do the calculations needed in all business, and to share sufficiently in the common knowledge of an educated man to be able to discuss affairs of state and of life intelligently. Just how much knowledge this requires obviously depends upon his social station and upon the ideals of the community in which he

lives. But all would agree that a certain amount of knowledge is necessary for the citizen if he is to be regarded as an intelligent citizen. In this sense intelligence is a matter of acquiring knowledge rather than of capacity, the sense in which we used the term in an earlier chapter. To this general minimum of knowledge should be added a minimum of skill, in writing and drawing, for example, which are the only skilled acts that the school necessarily holds itself responsible for.

Certain Useful Professions are Demanded.—In addition to the minimum of general knowledge and skill, the state may supply the most important forms of knowledge, the knowledge most important for the needs of the citizens, of medicine, of law and of dentistry, to mention the professions which are most generally recognized in practice as those which the state has an interest in fostering. Other forms of knowledge required in business are left to the individual efforts of the man to acquire, unless we regard the business courses in high schools and business administration courses in universities as aids to practical business life. The more detailed knowledge of trades and industry are now, for the most part, left to the chance of apprenticeships, when the present-day machine industry requires any longer apprenticeship than being shown how to start and stop the machine. Usually the learner is left to acquire any speed or skill that may be needed through practice. Engineering stands on a different plane and is recognized as a form of knowledge that should be fostered.

Can Education Increase General Ability?—In addition to the specific skill required in any given occupation or profession, and the specific knowledge that shall

be more generally useful, much emphasis is put in popular discussion upon a general increase in capacity that should be induced by the studies of the lower and higher curricula. In the minds of most men education is something vastly more than acquiring knowledge. It should remake the capabilities of the man, it should not merely teach him facts, it should draw out latent possibilities so that at the end of his course he will be an altogether different individual from the one he was at the beginning. In commencement orations, at least, one is impressed by the derivation of education as a "leading out" of the concealed capacities, that shall make the graduate of the institution what he would never have been if he had not been graduated, or at least from what he would have been if he had not had the required training. The psychological problem is to determine what change can be induced by training that will make a man thus different. We are told by one enthusiast for education that an educated man would even back a wheelbarrow up to a pile of dirt in a very different way from that which would be used by the uneducated man. If such a great change is really induced in the man one should be able to analyze it into its elements and learn what it is that produces it and why it is produced.

Does Specialized Training Have General Results?—Psychologists have reduced the problem of the change wrought through education to one of determining how far the effects wrought by learning one thing may affect the capacity to learn another, or how far doing one thing may influence the capacity to do another with which it has no common elements. This has been technically called the problem of the transfer

of training. We must leave the discussion of that problem, since it has become quite involved and technical, to a separate chapter. We can content ourselves here with the conclusion that it is still a question if learning to do one thing really does improve one's capacity to do another in any very marked degree, although there is evidence that there is improvement of varying amounts in closely related activities. How much that improvement is, varies with the material learned and the conditions of learning. Authorities differ as to whether it is sufficient to account for the desirability of an education or for the claim that is made for improvement through education in the more enthusiastic quarters.

Selection of Capable Individuals Confused with Improvement of Mass.—In measuring the effect of this increased capacity in the product of education, one needs to take into consideration a number of other factors which are very real in increasing the capacity of the graduates of any school or school system. The first and probably the most important of these is selection. As we saw in an earlier chapter, children are by birth of very different capacities. In a modern civilized community all start in the early grades of the school except those who are very decidedly low grade. In the course of the school work itself there is a gradual elimination of the poorest. They fall behind in the very first grade. Either in that grade or one slightly above they are compelled to repeat the work of a year. After they have repeated once or twice they become discouraged, and if the law permits they will stop and go to work. If they are compelled to remain in school to a certain age, fourteen, say, they will at that time have completed less

than the usual number of grades. Instead of completing the eighth grade, they will be only in the fifth or sixth. If one should measure the capacity of the average child who completed the eighth grade and compare it with the capacity of the average child of the same age in the sixth he will find it considerably higher in almost every respect.

One is likely to argue that this is the result of the two years' extra schooling, or to speak more accurately of the training in the subjects that are taught in the seventh and eighth grades. Obviously that conclusion is not justified. These children have greater intelligence because they were born with it, and they have completed two more years work because they have greater capacity; the capacity does not come because of learning the added subjects in school.

Difficult Subjects Repel all but the Capable. They Receive Credit for Improving Capacity.—Very much the same statement may be made concerning the effect of certain subjects in the advanced institutions of learning. It is frequently said that if one will compare the intelligence or capacity of students who have taken classical courses in high school or college with the capacity of those who take the commercial courses, you will find that they excel them in every respect. They do better in higher institutions, they do better in life, more of them make fortunes, and more of them find their way into "Who's Who," or become eminent when eminence is measured in any way. The argument is that if you would become eminent or achieve great capacity you must study the classics or study higher mathematics.

Involves Fallacy of Comparing Students of Uneven Natural Ability.—Again the argument reverses the relation of cause and effect. There is no doubt that the students who take the classical course or any other course that has the reputation of being more difficult are the more intelligent students. Certainly, study of the more difficult subjects does not decrease that intelligence, and they succeed in later life because they are more intelligent, not because they studied that more difficult subject. This statement is not made with any intention of deprecating study of classics or mathematics, but merely to illustrate the fact that there is always a selection of students even where one is not likely to suspect it and that any argument that fails to take that selection into account is certain to prove fallacious,—fallacious in method and logic if not in conclusion. To make any statement that would have validity upon the effects of studying any subject, one must select students of the same degree of intelligence as measured by school standing and by tests, then have one group study the subject in question and have the other pursue some entirely different line of work for the same time and then test on neutral material. Obviously this test has not so far been made in any adequate form.

To Select Only Less Important than to Create.—To assert that much of the effect of education in the popular mind is not due to the discipline obtained but to the incidental selection, is not to depreciate the importance of education. The men who graduate from the universities, undoubtedly constitute the selected minds of the nation. They are probably highest in intelligence, above the average in ideals and in morals and among

the best in persistence and in emotional balance. These qualities were not given to them by the studies that they pursued in the universities, nor even by the fellowship and discipline which they enjoyed in those years of training. On the contrary they were able to complete the university course only because they originally possessed those capacities. All other men were eliminated at different stages of the course or were not permitted to enter because they were not able to complete the curriculum in the lower schools whose work was a prerequisite to entrance. As a social institution the university is almost as important, its influence is almost as valuable, if it merely selects, as it would be if it really created these capacities. The nation may look to it for its intellectual leaders in the same way. One might just as confidently turn to it for officers for the army as was done in the last war, the business world can send to it for men to train for better executives with just as much confidence.

To gather together even half of the men of the upper five per cent of the intelligence of the nation in some two hundred or more institutions and know where to look for them when they are needed is in itself a highly important function. That alone would be worth to the nation what is spent upon the universities, were these men not improved at all by the time spent in the institutions. Selection then is one of the great functions of the educational system as it is administered now in all civilized countries and must be in any conceivable administration of an educational system. It is also a factor that must always be kept in mind when any conclusions are to be drawn from the effects of education based upon the character of the individuals who complete the course.

Must Not Credit Education with the Effects of Age.—A third factor that must be considered in education or in estimating the effects of different kinds of training upon growing children, especially, is the mere effect of natural growth due to increasing age. When any experiments are made upon a group of children or conclusions are drawn from tests made of capacity before and after any activity or training, it is necessary to have a control group who do not carry out the experiments but who are merely permitted to grow. You can ascribe to the training only the difference between the change in the group experimented upon and the control group. There is no doubt that many of the newer less formal systems of education profit by this without knowing it. They take credit for the natural growth of the child and regard it as part of the effects of their training.

Not all Education is in Schools.—Closely related is the effect of what is learned spontaneously without formal training or outside of school. This probably accounts for the many cases in which there seems to be no relation between the amount of time devoted to a subject and the progress in the subject. Rice reported that in schools in which only ten minutes a day was given to spelling, the children learned about as much, or were at least about as proficient as they were in schools in which a much longer period was devoted to it. This may mean that short periods of intensive work are as effective as longer periods of less intensive. More likely, however, it means that children learn to spell from reading and writing rather than from the formal spelling lessons. Arguments from these facts are apt to be fallacious either by emphasizing too much the importance

of formal training, if one ascribes all progress to the periods of training alone; or in assuming that all the benefit is derived from the work outside, from incidental living and so giving too little time to the formal work. There can be no doubt that a large part of the development of the young child comes from its natural growth and from what is learned incidentally outside of the periods of formal instruction. It is for that reason that the bright child may be out of school or skip grades without great loss. He loses a much smaller proportion of actual opportunity than we are inclined to think. This, too, probably makes feasible if it does not justify the informal instruction of the Montessori and similar systems.

Education as the Development of Ideals.—Other ends of education are to be found in setting up ideals of attainment for the youth that may persist into manhood. The ideals that are impressed by social pressure come almost altogether from intimate companions and from the elders with whom the child associates. If the child comes from an educated family in whom the highest ideals are present and they are inculcated from birth, the effect of the school is not so necessary. Even here, however, associations outside are bound to have an influence, and if they are with other children of less worthy ideals, the original higher ones will be contaminated. Where an intelligent child comes from a family of lesser intelligence or one in which the station in life has given no desire for high attainment or for the higher forms of service, it is the function of the school to inculcate them that the standards of success and the intelligence of the individual may not be out of harmony.

Not infrequently it seems from tests and observation that a child in a family of this type is content with a station in life lower than that which he might attain. This means a wasted intelligence, because there are fewer individuals than are needed, prepared for and capable of performing the highest functions in the community.

The Æsthetic Pleasure from Knowledge.—In addition we must take into consideration the æsthetic and so-called cultural aspects of an education. There is no doubt that were an education not to increase the capacity of an individual in any degree, or in any considerable degree, it would still be worth while for the pleasure that the individual obtains from it. This is partly social. There is something in having common topics of conversation and common interests, particularly common interests that set the individuals in some measure apart. Certain forms of education that continue the traditions of the past have this function in a very high degree. The ability to refer to or understand allusions to the events or the literature of the past may be of no practical value, but it does give a keen æsthetic pleasure. Much of the pleasure and interest in the older writers such as Montaigne or Burton in his "Anatomy of Melancholy" consist less in the contributions of the author himself than in the material that he has gathered from all possible earlier sources. Similarly, educated men have a bond in the common knowledge of literature and science that marks them off to themselves as a class, which may stand for worthy aims with the assurance that they are right. The class constitutes a force in the community. In this sense the body of educated men is an asset to the govern-

ment, and in all civic relations. To encourage it is a desirable end of popular education.

Education Should Impress the Dignity of Knowledge for its Own Sake.—To prepare the man himself to take part in the discussion and to be prepared to accept and to maintain the ideals of the cultured group is to confer a benefit upon him. To this end the teacher will do well to hold the ideals of knowledge, even of knowledge for its own sake, before the minds even of the younger pupils. It has the temporary advantages of escaping the frequent "why learn this" of the student who would learn only what is likely to be useful to him. It also prepares the way for the inculcation of the ideal that even worthless knowledge is worth while provided it is real knowledge, and makes the satisfaction of intellectual curiosity an end in itself. It is from the satisfaction of this ideal longing that most of the world's progress has come. The inculcation early of the notion that there is something desirable in knowledge for its own sake will provide the student with much satisfaction in later life, will give him an inspiration for the acquisition of knowledge for which at the moment he can see no use, and serves to give a dignity to the teaching profession and to the student's work that the more immediately utilitarian motives cannot supply.

What is Education?—If we look back upon the ends that are attained by education we find that it does supply certain bits of knowledge that are needed by every individual and which provide the basis for success in even the simplest professions or occupations. In addition, it does develop a mass of individuals in the community who are capable of the highest attainments,

We have seen reason to believe that this development of the individuals of highest capacity is rather a selection of them from the community than a creation of them from individuals who would not have had this capacity if they had not had the education. However it is brought about, the function of providing the state with individuals certified as capable in general as are the graduates of universities or as having some special attainment as well as general ability, is a function of the highest service to the state. It makes relatively little difference to it whether the intelligence is created or discovered; the community knows where to find it when it wants it. This is of the greatest importance.

We leave over the question of how far the general capacity of an individual may be improved by the training of some special ability or the acquirement of some special bits of knowledge. That must form the topic of a special chapter. Finally, we believe that it is no small part of the function of the school to spread a general belief in the efficacy of knowledge for its own sake. This, if effective, would foster the development of a group of citizens, who believe that it is worth while to know what can be known, who believe that there is an intellectual pleasure to be attained in the satisfaction of the higher forms of curiosity, and who shall themselves have a sufficient acquaintance with the results of science and of historical and literary studies to think with confidence and competence on the civic and other problems of the day and occasionally make contributions of new inventions and suggestions of their own. This is possible only on the basis of a knowledge of what has been done before. This latter ideal while apparently lost sight of by many

in the press of a practical world, is, in the opinion of the writer, not the least important of the functions of education. Inculcation of the ideal cannot begin too early.

QUESTIONS ON CHAPTER VI

1. It is stated that the men who led the mathematical tripos, the highest mathematical honor at Cambridge, have proved exceptionally successful judges in the Indian service. Is it because of the mathematical training or because the rivalry selected the men of exceptional general ability?
2. Do Montessori children progress rapidly because aided by sense-training or are they merely permitted to ripen?
3. Is education only acquirement of special skill?
4. Is it worth while to imbue a high school student with respect for knowledge as such, even abstract knowledge?
5. Why are the poorer students among high school graduates in the business courses? Is it because of lack of classical training or because business courses are believed to be easy?
6. Why be educated?

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CHAPTER VII

THE PLACE OF HABIT IN EDUCATION

Habit the Final Stage in All Real Learning.—The tendency of all movements and of mental operations which involve little or no movement to become mechanized so that they go on of themselves after frequent repetitions, no matter how much effort may have been involved in their first performance, is known as habit. It is a fact that has the utmost importance in all learning. Its application to the processes of learning and teaching are numerous and fundamental in their importance. Everything that is learned must not only be remembered and appreciated or approved but also be repeated until it takes place without thought of itself on the proper stimulus. Until that stage is reached the acquisition is only partial; it is not fully available in increasing the effectiveness of the individual.

Habit a Closer Interaction of Neurones.—Physiologically, the formation of a habit consists in having different parts of the nervous system active together until they grow together to constitute a functional unity. The physiologist tells us that the nervous system consists of billions of separate units or cells which we know as neurones. These are largely independent entities. Each is self-sustaining except so far as dependent upon the blood for nourishment, and upon the bones and related structures for physical support, and for being

kept in position. Each develops independently from an earlier cell, and retains much of its independence through life. In its growth each sends out long processes or elongations of itself which bring it into connection with sense organ or with muscle and with other neurones near it or remote from it.

The Neurone and its Parts.—Each unit consists of

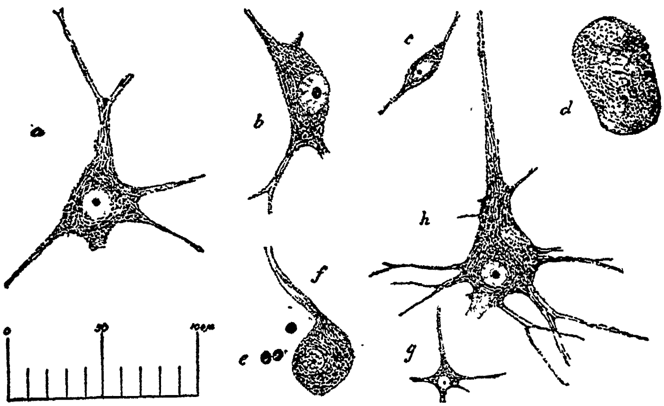

FIG. 6.—A group of human nerve-cells drawn to the same scale; (*a*) small cell from ventral horn of the cord; (*b*) cell from Clarke's column, thoracic cord; (*c*) small nerve-cell from tip of dorsal horn, thoracic cord; (*d*) spinal ganglion cell, cervical root; (*e*) three granules from cerebellum; (*f*) Purkinje cell from cerebellum; (*g*) small pyramidal cell from second layer of central gyri of cortex; (*h*) giant pyramidal cell from the same region. (From Donaldson, in the "Amer. Text-book of Physiology," after Adolf Meyer)

three parts, the cell body and two processes or extensions from the central body. One of the processes which we call the axone is long with occasional branches nearly at right angles. At the end of the main fibril and of each of the branches is a number of delicate fibrillæ, the end brush. The axone may extend half the length of the body. It always carries the nerve impulse away

from the cell body. At the other end of the cell body are other processes, the dendrites, short and branched, which carry impulses towards the cell.

All action of the body is made possible, we believe, by the passage of an electrical and chemical change which we call the nerve impulse from a sense organ through a chain of these neurones to a muscle. This impulse can be started by an excitation of a sense organ, and in that way alone. It passes through one after another of the neurones to a muscle, and when the excitation passes from the neurone to the muscle with which it is connected, the muscle contracts.

Openness of Connections Determines Action.—Ultimately the whole function of the elements of the nervous system is to connect the sense organs with the muscles in such a way that a sense impression may be conducted to a muscle and there produce a contraction of that muscle. In the lower parts of the nervous system, particularly in the cord, certain of the connections of neurones are already established at birth. The sense organ is at the end of the long dendrite of one neurone. When stimulated this neurone transmits an impulse through its axone to another neurone. This second neurone in turn connects with a muscle by its axone, and between the two neurones there would be a contact of the tissue at the point where the axone of one and the dendrite of the other meet. At the point of contact there is relatively slight resistance offered to the passage of the impulse. This point of contact between axones and dendrites, we know by the technical name of the synapse. In most cases even where there is contact between axone and dendrite, there may be considerable

resistance offered to the passage of the nervous impulse. In certain cases there is none or relatively very little. The latter condition of slight resistance is found at birth in the cord and brain stem, in general between neurones which connect directly, one with a sense organ, the other with a muscle, and are themselves in contact. Movements through them are made at once upon the

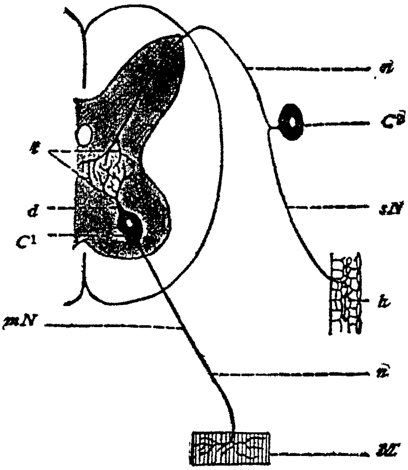

FIG. 7.—Shows the simple reflex connection through the cord. C^2, T-shaped cell in spinal ganglion; *sN*, long dendrite or teledendrion to *h*, sense ending in skin. C^1, motor-cell connection by axone *n* with muscle *M*.

first stimulation of the sense organ after birth. Movements of this type are what we call reflexes.

Selection of Reflexes.—Even in the case of reflex movements, it is found that there may be several neurones which are in contact in this way, one sensory neurone may be connected with several motor neurones. We believe that in this case, the different synapses or points

of connection offer different amounts of resistance to the passage of the impulse, and that the movement which results is determined by the motor neurone the path to which from the sensory neurone offers the least resistance. If for example a sensory neurone which receives stimuli from the skin of the chest is connected with a motor neurone that leads to the muscles of the right arm, of the left arm, and to the muscles of the chest, respectively, and if the connection with the muscle of the right arm offers the least resistance, a slight stimulation of that spot on the skin will lead to the contraction of the muscles of the right arm and the right hand will be brought up to touch the chest at that spot. If now a stronger touch, such as a moderate pin prick, be applied to that point of the skin, the left arm will be brought over in addition, or at least there will be a movement of the left arm. If the stimulation be still stronger or persists for a longer time, the muscles of the chest will be contracted as well. We think then of the degree of openness of the synapses between neurones as being responsible for the contractions of the muscles in reflexes, and that the kind of reflex which results from any stimulation is due to the degree of openness which may exist between the neurones at the synapse.

Association through Intermediate Neurones.—Neurones which may not be directly in contact may be connected by chains of other neurones, and in the course of time a series of connections at different synapses may be established that will make possible movements which were not likely to be made before experience. In the course of the life of the individual, impulses spread for unknown causes from neurones to neurones, and after

the movement has once been made by chance, the path persists and, if the results of the action give an instinctively pleasant result, that movement will be repeated. Each time it is repeated the impulse must pass from neurone to neurone across the synapses concerned and each passage of the impulse across the synapse makes the connection closer, makes the synapse offer less resistance and so makes the same movement recur more often. This opening of synapses through use is what is at the basis of habit formation. Habitual acts are hit upon by chance, but, when they have been performed, they change the character of the synapse, so that each new stimulation of the original sense organ or of the sensory neurone tends to give rise to the same action.

Nature of Change at Synapse.—What the nature of the change which takes place at the synapse may be we do not know directly. Sherrington assumes that the neurones have a membrane which extends around the processes as well as around the cell body, a membrane like the inclosing membrane of the amœba or any single-celled animal. When the impulse passes a change takes place in the membrane which tends to make it easier for any impulse to pass again. Probably this change is in the chemical constitution of the membrane, due to the effects of the chemical changes or electro-chemical changes in the constitution of the cell tissue on either side of the membrane. What it is matters little for us except that it is possibly a little easier to think of the results in such a picture of what takes place, than to leave it unrepresented or not pictured at all.

First Non-Reflex Movement Made by Chance.—As seen in practice, habit is merely the change by which

any movement, however difficult it may have been at first, comes to be made at once without effort and often without thought. The general rule is that the first time a non-instinctive movement is made intentionally, it is made only after a number of trials, usually accompanied by many unnecessary movements or contractions, which, just because they partly check each other, are accompanied by a feeling or sensation of strain. As they are made more and more often, they are made after a shorter and shorter interval, with fewer and fewer trials and with less strain, until after frequent repetitions, they result at once when the stimulus is presented. Finally we may not even know that the movements completely habituated have been made. They may take place when we have no intention of making them.

Habits Result from Tentative Movements.—The process of making the first movement deserves a moment's consideration, because it is typical of many of the operations in all of our active and thinking life. It is not a series of well-considered acts, such as man as a reasoning being would be expected to make. On the contrary it results from a series of random movements, the first of which may be little like the movement intended and which only gradually approximate the end desired. The fact that learning takes this course, known as the method of "trial and error", was first developed in experimental studies of the learning of animals. When an animal, a dog or a cat, is put into a cage with a door fastened in such a way that it may be opened from within, the animal will begin a series of acts that have no relation to the end that is to be attained. Finally one of these movements by pure chance will unfasten the catch and

open the door. Usually, when the animal is rewarded for his success by being fed and put back again, he will not succeed at the ensuing trial, but must go through another series of trials before he escapes. This time the movements may be made in larger number about the catch and a greater percentage of them will resemble the movement that succeeded the first time, but still many trials will be made before the animal escapes again. Gradually the number of trials needed will decrease, until after a time, the correct movement will be made almost at once when the animal is put into the cage.

Man Learns by Trial and Error.—One might think that this trial and error process of learning would hold for animals alone and that man would learn rationally, at the first attempt. This is true only in small degree. Many things man learns with fewer trials than does the animal, but the process is approximately the same for all. When a man is trying to learn a new sound in a foreign language, the French nasal or the French *u*, for example, he will at first make a sound that he already has at his command which is as nearly like the sound as possible, then he will begin a series of trials that shall modify that sound in the desired direction. After a number of trials, possibly extending over several days, he will succeed, but that initial success will not constitute complete mastery. He will succeed at one time and fail at others for weeks before the mastery is complete. All learning follows this law. How many movements will be required will depend in any case upon how closely some movement which he can make at the time he begins resembles the movement desired, and upon a number of

other chance factors. In every case, certain trials will be required before the first success, and many others before each attempt will be rewarded by attainment. Learning is usually a long process.

Habit Omnipresent.—Equally as striking as the difficulty of the original learning is the completeness with which habit dominates when once it is acquired. Then it is difficult to make any other than the habitual movement when the occasion recurs. If a child by effort learns to pronounce a word as the custom of his parents demands, he will with still greater effort break that habit when he moves to an environment which demands another pronunciation. Habits of speech once formed persist in spite of all efforts to change. Even bad habits of grammar which are learned early will crop out again in moments of excitement in spite of the much more numerous later repetitions of correct combinations and of the chagrin which they may occasion to the speaker and his friends. Speech, whether one includes in the term only the making of single sounds, or the use of phrases and larger units is almost entirely a matter of habit. The different sounds, at first practiced separately, gradually become united by habit into larger units each of which is evoked by the sound that comes before it and by the intention of speaking. Through the formation of habit no attention need be given to the separate acts. A single thought is sufficient to start the entire group.

Speech as Habit.—The act of learning to speak a foreign language with fluency emphasizes well the difference between learning that has become habit and mere knowledge of the words and rules. One may read a language, one may know the various forms and grammatical rules

and still find that speech is practically impossible. Each word may be spoken in a fashion, certain phrases may be known as wholes, but one may still be far from the point where the language can be spoken with assurance. At this stage the words come singly and only after much casting around in memory for the suitable single element. The process is much like the trial and error one of learning. Before the language can be used with any facility it is necessary to have practiced most of the phrases as combinations. The idea then evokes the phrase as a whole rather than a series of separate words. Knowledge of the rules of grammar and of the separate words is necessary before the habits can be developed, unless one is learning as a child learns, but to know them is not to be able to speak the language until the habit of speaking the phrases has been thoroughly established.

Habit Formation in Writing.—Similarly the process of learning to write is one of first forming the movements by effortful attention to each single stroke, and then tying the separate movements together into larger wholes that may be evoked by a single stimulus or single intention. At first the child is incapable of holding the pencil properly, or of making accurately the separate movements out of which the various letters are constructed. Partly as a matter of the development of the nervous system, partly as a result of the development of other related habits involving the finer movements of hands and fingers, and partly as the result of the formation of the specific writing habit these primary movements become possible. The development of the writing movements themselves follows similar laws and is at every stage dependent upon habit. Whether one writes

with the fingers or with the whole arm, whether one takes pains or writes carelessly is a matter of habit as well as the particular movements that constitute the writing itself. Care taken at first makes possible the development of a system of habits that result in clear and beautiful handwriting with no more effort or attention than is required for the poorest. Once thoroughly established the writing habit is so constant that we trust the signature as an evidence of the genuineness of financial documents. A man will make his signature so much alike on each occasion that it may always be recognized, and even with the greatest care it is seldom accurately enough imitated by the man who would forge it to escape detection.

Acquiring Skill is a Result of Habit Formation.—The training of an individual in any skilled movement is entirely due to habit formation. Knitting and needlework are acquired only at the expense of considerable time and effort. Once acquired, any occasion evokes the proper series of movement with machine-like accuracy. The skilled knitter works as well when talking or reading as when giving entire attention to her work, although full attention and great pains were necessary to acquire the skill in the first learning, A large part of the training of the skilled workman in any trade consists in the formation of similar habits. Something depends upon mere knowledge of what to do, but that is relatively quickly acquired. In addition, the adaptation of movement to stimulus, of hand to eye and to thought is what requires the long periods of training needed to make the skilled artisan in any field.

Where the work is relatively unskilled and much de-

pends upon the use of machinery, the man who tends the machine has his movements so completely dominated by habit, his movements are so completely adjusted to the movements of the machine, that he becomes almost a part of it. He thinks of his work little more than does the machine; the movements will be made for long stretches without his being aware that they are made. It is work of this type that can be executed by the moron as well as by the men of the higher levels of intelligence.

Habit in Study.—Habit in the more intellectual activities is almost as important as in the mere movements. One forms habits of ways of work and of times of work, habits of self-control and of giving way to emotions, habits, in fact, of every conceivable operation.

Most Improvement Through Education is Due to Habit.—From the standpoint of teaching and studying, taking advantage of the possibility of formation of habits is one of the most important and probably the most neglected phases of mental life. In giving advice to students in all grades we are prone to stop with the mere formulation of rules, without insisting that the rules be put into practice. Very few students, and usually those that need them least, will actually follow the rules in their own studying even if they are able to recite them perfectly. The rules given in the following chapter on memory would, if actually followed, save anywhere from twenty to forty per cent of the time actually spent in the schools in memorizing. Unfortunately, at present, the students usually become acquainted with these rules late in their university course, after most occasions for rote learning is over. Even then, they usually do not follow them closely, if at all, because they have already devel-

oped habits of learning, which they are not willing to change and probably could change only at the expense of considerable effort. All rules of study, if they are to be useful, must be established as habits and not merely taught as academic knowledge. The child, for that reason, should early have a certain amount of supervised study that these habits may be thoroughly formed when he first begins his life as a student.

Habit and Teaching.—The same remarks should be made about teaching. Knowledge of the best methods of teaching may be the first step in being a good teacher, but unless the knowledge is translated into habit, it is largely wasted. So true is this that it is said, possibly by unkind critics, that a few of the men who stand highest among the authorities on methods of teaching are themselves very bad teachers. We need not accept this as a fact on hearsay evidence. Still there is nothing impossible in the statement. If true, it would mean merely that the man who knew had not translated that knowledge into habit. Many teachers either from indifference, from laziness, or because old habits are thoroughly established, do not teach as well as they know how; while it must be added that others, who know little, may by chance have hit upon good habits without knowing the reason for them. While knowledge based upon assured facts of psychology and related sciences, confirmed where possible by actual educational experiments, must be the basis of the laws of teaching, this knowledge must be transformed into habit by the individual teacher, if it is to be really used effectively.

Habit in Intellectual Processes.—More generally, one falls into habits of thinking for one's self or of accepting

the opinions of others, which, once established, make or mar the intellectual life of the individual. Again a certain amount of intelligence is required before an individual can think for himself to advantage, but even individuals who are capable may form the habit of taking statements on authority when they have sufficient knowledge and ability to think for themselves. Habits of thinking for one's self may be developed in the student, if he is encouraged in it as soon as he is able, and rote memory and other forms of trusting to others for results and opinions be reduced to a minimum. Habits of neatness in work may be developed at least for the particular form of task in which one forms the habit of being neat. In fact habit formation is possibly the greatest aid in developing the individual in the matters of routine. One side of every phase of every education is nothing more than the development of habits, a development that in every case consists in inducing or forcing the individual to execute the process repeatedly until it comes to be taken as the proper thing to do and is done without thought, even, in time, without knowing that it is being done.

The Utility of Habit.—Much has been said in the different works on psychology and education of the advantages and disadvantages of habit. On the one hand it is said that habit formation is deleterious since once established a habit compels the individual to carry on the movement or the mental operation in the same way each time. This reduces the place of thought and in a measure restricts the individual's freedom for the present by the domination of old-established habits. Where the habits are bad, one recognizes the disadvantage at

once. The drunkard or the drug addict suffers from being bound to his past. Could he remove from his nervous system the results of old acts and start afresh, he would again be a free man. Again, it is at times a disadvantage that habits, which on the whole are good, often become displaced and cause acts in places to which they are not suited. A comparatively harmless instance is turning on the light when one leaves a room in the daytime. Leaving the room at night has established the habit of putting the hand to the switch of the electric light and turning the button, a very good habit. The habit transferred to the day involves leaving the light on unless the flashing of the light calls attention to the effect and evokes the reasoned reaction. Other more serious cases can undoubtedly be supplied from the experience of the reader. It must be admitted that this is a disadvantage that results from the general tendency to form habits.

Habit Universal and Inevitable.—On the whole, however, the advantages of habit so far outweigh the disadvantages that the latter are hardly to be considered. Were one compelled to think of each act and each part of an act, there would be a vast amount of time required, and much that is essential would be omitted because one did not think of it. As a matter of fact it is impossible to think what an individual would be like without habit, for the same tendencies in the nervous system that make habit possible are also responsible for the memory processes. As is evident and will be developed further on, without memory all thinking would be impossible. To indicate how inconceivable it is to assume the possibility of being without habit and attempt to

justify it, one need only point out the fact that habit makes possible and even compels the grouping of series of movements into units which may be excited by a single impulse. This grouping begins with the very simplest elements of an act, the contraction of single muscles in groups as well as with the combination of the larger units into groups. In speaking, for example, it is necessary to adjust movements of the chest that force air through the larynx and the other vocal organs at the same time the vocal organs themselves are adjusted for the different component sounds of the letters. The different sounds are then grouped into words and these into sentences. One is not even conscious of most of these movements, and were one compelled to think of how they should be put together, there would be no time left for considering what should be said. In general this illustrates the value of habit. It saves thinking, and when thinking is required, it makes one thought or idea do the work of a number. In a sense it may be said that habit makes possible the utilization of all earlier learning. Each successful movement, no matter how first made, leaves its effect in the nervous system, and becomes useful for all other occasions of the same type.

For education habits of physical action constitute the most important single factor. Habits of a more intellectual type, habits of attending in a particular way or to particular things, habits of learning in a given way, habits of neatness, habits of obedience, and of the proper amount of independence of attitude, with many others constitute a large part of what in the sum constitute the characteristic differences between the educated and the uneducated and between the properly educated and the

wrongly educated. As instinct may very pictorially be said to enable the individual to profit from the experience of the race, habit makes it possible for the individual to profit from his own experience.

QUESTIONS ON CHAPTER VII

1. What happens in the nervous system when a habit is formed?
2. How do habits help in speech?
3. Can you form habits of study?
4. How does reason help in habit formation? How far are these habits developed by trial or error?
5. How far are habits developed by trial and error?
6. Illustrate how habit may work in morals.
7. Give indications of the value of habit in study.
8. Can you form habits of good temper?
9. What habits should the teacher form?
10. Give rules for breaking bad habits.
11. Enumerate ten physical habits you have shown to-day.
12. List six intellectual or moral habits you have shown to-day.
13. Criticise the following question sent out to applicants for a University position: "Do you smoke? Do you drink? Do you have any other habits good or bad?"

REFERENCES FOR CHAPTER VII

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Angell: *Psychology*. Chapter III.
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CHAPTER VIII

ATTENTION IN EDUCATION

One of the mental functions that is involved in every act of the student at any age is the selection of the material that shall enter consciousness. The awareness of an individual is strictly limited. He can see or hear only one thing at a time. Many objects are presented to his senses that he does not notice, and there are many other things that he never notices that he might become aware of if he fulfilled the necessary conditions. Obviously, if the child or man is to be instructed, he must be induced to attend to the material that he is expected to learn. Furthermore, some things are seen clearly and frequently, others are seen but vaguely. Effective education must imply full attention to what is essential to the proper instruction, and merely passing or limited attention to what is undesirable for the purposes of education. It is evident, then, that attention is as fundamental to education in its way, as habit and memory are in theirs.

Attention Synonymous with Selection.—For our purposes we may neglect the more technical definitions of attention and the finer shadings between theories, and content ourselves with accepting attention as synonymous with selection of what we shall notice. We can then devote ourselves to a discussion of the more definite laws that control this selection, and the practical rules that may be drawn from them. One distinction we may

mention in connection with awareness. This is the distinction between awareness in itself and efficiency of noticing, between the fact of selection and the degree of knowledge that follows upon awareness. Many things we notice at the time of which we retain no lasting memory. Others are attended to in a way that may have a lifelong effect. The latter is the form of attention that is essential for education, and so the type that shall most concern us.

Attention Limited in Duration.—Two facts which have an important bearing upon the way attention may be applied are the marked limitations of attention in range and in duration. The process of perceiving or of thinking is not a continuous process as we are inclined to believe before we experiment or make careful observations, but is always by a series of pulses. Whatever may be the purpose of the moment, it will be noticed that one does not hold the same object or idea constantly in mind for a long period. Rather, one thing after another is noticed for a few moments and then drops out to be succeeded by something else for another brief instant. The extreme limit during which one may attend to the same thing or the same phase of a thing is probably in the neighborhood of a second, probably even less. If the reader will attempt to look constantly at a small speck for a minute, he will observe this fluctuation after a short interval. He will have the dot in mind entirely for a second or thereabouts, then he will wonder whether he has been looking at it, then he will see it again, then a strain in the forehead will attract him, and so on. As he looks back he will find he has been oscillating between the dot and other objects in the surroundings, and sensa-

tions from other organs, and thoughts and memories of all sorts. Most of these will be related in some way to the dot or to the experience, and so he would be inclined to say, if his interest in the process has not been specially directed to the changes, that he has been attending to the dot all of the time. A careful record which counts the different appearances of the dot as distinct and includes other things noticed or thought of would give a list of fifty or more objects and ideas that had passed through consciousness in the minute, and many, ideas in particular, will have been overlooked. The probable explanation is that the elements of the nervous system fatigue and recover very quickly. Each pulse of attention corresponds to a discharge of a nerve cell, which, after the second or less required for the discharge, is incapable of action for a second or more after which it may act again.

Fluctuations of Attention.—In addition to these shortest pulses of attention, there are also longer rhythms of efficiency, which are not marked by complete incapacity for observation, but merely by reduced capacity. If one will look at a faint gray dot, it will be noticed that it disappears at times and then appears again. These longer waves come every ten or fifteen seconds and can be observed in listening to the very faint ticking of a watch held at a distance so great that it can just be heard. Probably related to them are the alternations in the interpretation of those experiences which are open to different interpretations. If one looks at a figure of two squares drawn one within the other that can be interpreted either as a convex or a concave surface, it will be noticed that it is seen first in one way, then in another, and that the fluctuations take place every ten or fifteen

seconds. These fluctuations are of much less practical importance than the others, but are of incidental interest.

Continuous Attention Impossible.—The fact that attention comes in pulses is of importance in all discussions of attention, particularly for our purposes. One should not expect continuous attention in the absolute sense, especially of a child. The most that is to be required is a series of returns to the subject that is being considered or to the object that is being observed. Where the object is constantly changing or the course of thought is constantly shifting its direction, as it must usually, there is of course the possibility that attention to the general topic may be continuous, the child, and frequently the man, may be so engrossed in his observations that he will not notice changes in objects about, will not hear a call to dinner or notice when some one enters his study. Even here, attention is not given to the same thing without change, but to a series of different sensations or different ideas which are connected by a general unity which makes us regard them as one.

As a rule, the younger the child, the shorter will be the time given to any single object and the fewer will be the pulses of attention turned in the same general direction. He will learn most by giving attention for a brief period to each thing that he is expected to learn, and coming back to it often with these complete but brief periods of absorption. In any case distractability is to be expected of the child,—only gradually will he come to give attention for any considerable time. To attempt to force the assumed method of the adult upon him too soon, will merely give him a distaste for his work without

accomplishing anything. One of the advantages of the play methods of teaching is that they recognize the fact that the child attends but an instant, and permit him to use those instants to the utmost, with long intervals largely unused in between. As he grows older, the number of successive acts of attention that may be given to the same larger object will increase until as an adult he may seem to be attending continuously. Even here, it may be insisted again, attention is by pulses only; the apparent continuity comes from the unity of the different results or the unity of the object to which they are directed.

A Limited Number of Objects May Be Attended to at One Time.—The range of attention at a single instant is similarly limited. One can attend to but one thing at a time. There seem at first sight to be exceptions to this statement, but on examination they are seen to be apparent only. If one will show for as short a time as possible a group of objects, and then ask the observer to say how many he has seen, it will be found that answers are accurate when there are as many as five single small objects. This might seem to be opposed to our law, and was at first so regarded. More careful study of the method by which the answers were obtained, however, indicates that the observer receives a mental picture which lasts for a little time, about two seconds, usually, and counts the objects from this image after the exposure is completed. Each object requires a separate act or pulse of attention, so that there is really only one object attended to at a time, and as many pulses of attention as there are objects. The reader can convince himself that this is the method followed if he will

study the way in which he observes or counts or even if he will watch another. He will see that the observer looks fixedly into space for two seconds or more after the objects have been shown him, and will be ready with his answer only after this interval.

Only One Thing Can Be Done at a Time.—Another apparent exception was suggested by the observation that, on occasion, one could do two things more quickly if they were done at the same time, than they could be if done successively. Thus if a man add a column of simple figures at the same time that he is reading an easy selection, he will use less time than if he does the addition first as quickly as he can and then reads the selection. The exception in this case, too, is only apparent. One saves time by doing one thing while the other does not require attention. One reads in the intervals when the addition is going on as an habitual process. When each operation is sufficiently difficult to require constant attention, time is lost rather than gained by doing them at the same time. We see then that attention is always a unitary process, and that the apparent exceptions are to be explained from the fact that the rapidly succeeding pulses of attention turn so quickly from one thing or idea to another, that we do not notice that there are different pulses.

Effect of Training on Range of Attention.—From its educational side, one of the important questions in connection with the distribution of attention is as to whether it can be improved by training. There has been from time to time in educational circles belief that one can by training increase the range of attention in sufficient degree to be of general value. It is said that one can

practice counting the objects in a shop window, at a single glance and that this, after much training, will increase the range of attention in considerable degree. What we know of attention and the experiments that have been made, however, indicate that this training is of very limited extent. The number of objects that can be seen in a store window will be greater after long practice than before, but it would not increase the number of dots that could be seen in a brief exposure with a piece of laboratory apparatus or of different objects or of objects seen under any other conditions. A long investigation by McQueen of the effects of training by different tests, and by different methods, indicates that what would seem to be different measurements of the width of the attention do not give the same results. Training one does not improve the others, and an individual who stands well in one does not necessarily stand relatively well in others.

It would follow that what we call distribution of attention is a different capacity in different connections, even if certain of the elements are common, and, in consequence, that training one's self to see more things would increase the capacity only for seeing the particular things for which the individual had practiced. As a matter of fact, training in any one kind of material improves the capacity for seeing that particular kind of material, but has relatively little effect upon seeing any other kind or for seeing under different conditions. The quickness with which training comes makes it unnecessary to train in advance, particularly as the effects of training wear away very quickly. On the other hand, the fact that there is little or no spread of the practice

effects makes it impossible to prepare in advance for all situations, and so adds to the arguments against special training.

Grouping Increases Span.—One effect of training that seems to affect the width of the span of attention in a more particular way is the grouping of what is seen into larger units which may be taken in and interpreted as wholes. In some of the early experiments on the problem it was noticed that familiar groups of dots, such as arrangements in squares with a center, could be appreciated as readily as single dots. Four or five dots or four or five groups of five could be accurately detected at a single exposure. In the same way as many letters can be seen at a brief exposure as dots, and as many short words as letters. This effect of training probably does not affect the width of the attention span as such. Rather it serves to form associations between the different elements that make the group as a whole evoke a single name or a single response, so that they are counted together at a single act. This is really training of perception, not an increase of the span of attention.

A Narrow vs. a Broad Attention Span.—One other problem of some practical importance relates to the suggested classification of individuals, into those with relatively wide range of attention, and those with relatively narrow. G. E. Müller, among others, has stated, on the basis of observation, that this difference is fairly general. The individual of a narrow range is also usually very persistent, changing relatively slowly from one topic or one object to another. The individual of wide attention range, on the other hand, would also change quickly from object to object, and would never from

desire dwell long on one topic. Müller asserts that he himself belongs to the first group, that he can accomplish relatively little unless he can give considerable time to a task, and that he is likely to brood for some time over the first task, if he attempts to turn to a second before it is completed. Coupled then with a narrow range of attention, is what has been popularly called the one-track mind, a relatively slow change from one topic to another, and a considerable inertia in mental processes in general. Although McQueen did not find that width of attention was a single unit factor, it may still be possible that the other classification may be confirmed by statistical investigations of other kinds. Careful observers confirm it. If it holds it may well be taken into account in school work.

Motor Accompaniments of Attention.—The more general features of attention may also be considered by the teacher. One interesting general problem is the relation between attention and movement. Each act of attention is accompanied by movements, slight or more extended. The movements are in part adaptations of the sense organs which make them more effective as receptors of stimuli. The eyes turn towards the object in which for any reason we become interested, and the lens adjusts itself to give a clear image of it. In less degree, each of the sense organs changes to give the greatest efficacy possible to the stimuli that are received from the organ.

In addition, there are widespread changes in circulation and respiration, which increase the capacity of the nervous system and of the body as a whole, to receive and to respond to the stimulus. The periphery of the

body has its circulation decreased while the circulation of the brain increases as soon as attention begins. The breath is held that the noise produced by the passage of air through nose and throat shall not obscure faint sounds, or the movement of the head incidental to respiration make the eye unsteady. In addition there is a general contraction of all of the larger muscles of the body, especially of the muscles of the forehead and of the jaws. The contraction of the muscles of the body as a whole, has the same effect as the cessation of respiration in making the body steady and preventing noises which might drown slight sounds. They are also of particular interest in that they give rise to the mass of sensations of strain which constitute the feeling of effort that accompanies the higher degrees of attention and attention under difficulties. When we experience these contractions or the "effort" that is induced through them, we become aware that we are attending. We also regard the sensations of strain as an indication that we are exerting ourselves to attend or to acquire.

Educationally, the movements that accompany attention are of most importance as external signs that attention is being given and of the direction that it is taking. One can tell from watching the eye of a boy what is interesting him at the moment. True, one can snatch glances in a forbidden direction under the eye of a vigilant teacher, but not for long or to great advantage. While a discipline of attention that rests upon prohibitions will not be particularly effective for positive attainment, it may have an incidental place. As a sign of general attention, the absence of noise due to the innumerable slight movements of a room full of inatten-

tive students, has a larger place. A quiet room is usually a studious or attentive room. Though one cannot enforce attention by prohibiting noise, one can prevent noise by insuring attention.

The Conditions of Attention.—Practically the most fundamental phase of the art of teaching is to attract and hold the attention of the student. Without it all else is in vain, with it something may be accomplished in spite of all other defects in method. While skill in this most important process is acquired by trial and error, and fixed by habit, many suggestions can be given from a study of the laws of attention. A rational justification of the methods that have been developed through mere experience is also of value. By conditions of attention we mean nothing more than a statement of the circumstances which will result in attention, with an explanation of why the cause produces the effect. For convenience, we may divide the conditions of attention into the objective and subjective. The objective need detain us but a short time, as they are for the most part conditions which we struggle against in education, rather than those which we use to further our ends. The objective conditions are made up of the stimuli in the outside world which assail our senses. At any moment, what shall enter consciousness is determined by the relative strength of the opposing sets of conditions.

The Objective Conditions.—The aspects of the outside world that attract attention are the intensity, the size, and the duration of sensations. The stronger the stimulus, the more likely it is to be noticed. A strong light, a loud shout, a penetrating odor will attract us, where fainter ones will pass unnoticed. It is, however,

not the absolute values so much as the contrast with the sensations that precede, or those present at the same time, that control attending. One is as certainly attracted by a diminution in intensity as by an increase. The inattentive boy in a class is as much attracted by a pause in the teacher's discourse as by an increase in its intensity. We notice the passing of the sun behind a cloud as frequently as its reappearance. Any change must find us ready to act in the suitable manner. Therefore only those individuals have survived who noticed changes of any kind. The others were destroyed by the large animals that approached unobserved, or by failing to notice the approach of smaller animals that might serve as food. In addition to intensity, the size of an object is a factor in determining whether it shall or shall not be noticed. Large objects are more likely to be noticed than small, although experiments in connection with advertisements show that the likelihood of being seen does not increase so rapidly as the size. Within limits, increase in the duration of a stimulus also makes attention more certain. Attention is, however, not held by a stimulus that does not change, which means that there is a limit beyond which increase in duration does not favor attention.

The Subjective Conditions of Attention.—Opposed to these more external forces which would compel attention whether we would or not are the influences in us which we accept as part of ourselves. These, too, can be reduced to law and so understood. In general, we may say that the subjective conditions are the expression of the previous experience of the individual. The simpler can be readily demonstrated. The nearest in

time to the act of attention is the idea that immediately precedes the stimulus that receives attention. If one has observed an object attentively at one instant and it reappears after a short interval, it is very likely to be noticed again. This can be seen very readily in a puzzle picture such as is shown in the accompanying figure. After you have once found the outline you will see it each time, although you may have looked long for it

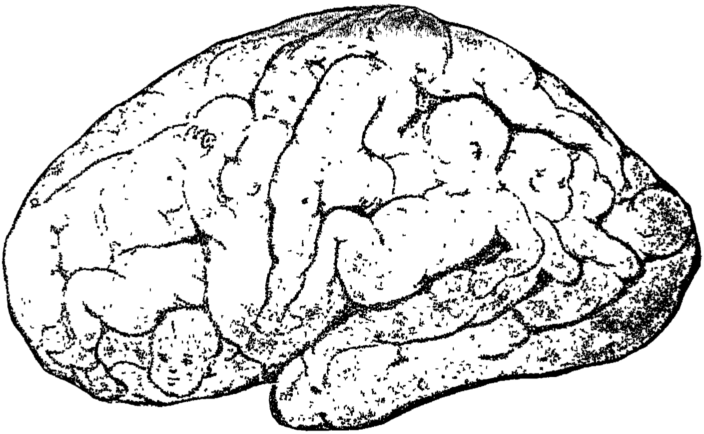

FIG. 8.—Puzzle picture. (From Titchener, after Gudden)

before you first discovered it. Similarly if you can recall a definite memory of the object you desire to see, you will see it much more quickly than if you do not know what you are looking for. Both the immediately preceding sensation and the idea in mind are effective because they partially excite the corresponding elements of the cortex, so that when the sensation presents itself from the outside world it finds them prepared to respond, and they act quickly and strongly upon the stimulation.

The Influence of Purpose or Mental Attitude.—Slightly more remote in time are the influence of the task set by the individual himself or another. One sees what one is asked to see, while all else passes unappreciated. Show a child a number of bits of paper of different colors and shapes with the request to tell you what the colors are, then half an hour later after the images have faded from the primary memory ask him what the shapes are and he will have little idea although the colors will still be remembered. Or look at the small squares in the Figure 9. These questions are quite as effective when they rise spontaneously as when they are asked

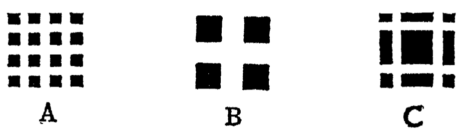

FIG. 9.—The Schumann figure, to show the effects of attending differently. If you look at A with the intention of dividing into four squares an effect is seen similar to B. With a different intention it takes on the form of C, as easily.

by some one else. Thus as one looks at one's watch to note the time, one learns that but sees nothing else. The average man cannot tell whether the numerals on his watch are Roman or Arabic, or the four is *iv* or *iiii*. Some will even hesitate when asked what the six is like, although it is not present at all on most watches because the second hand takes its place. If one asks a class this question, one will see the watches coming out of the pockets to see what the figures really are. If, then, one asks a man who has been looking, what the time is, he will nine times out of ten reply that he does not know, that he did not notice. He had been looking to see

what figures were used and had had no question of time in mind. One sees primarily what corresponds to questions set by one's self or by others. All else is refused entrance to consciousness.

Educational Bearings.—The educational bearing of this group of facts is of the greatest importance and is central for many systems of teaching. In general, it means that you cannot expect a student to see or hear unless you either give a definite question for him to answer, or he has sufficient knowledge of the subject to raise important questions for himself. The futility of asking a student to observe when he does not know what to observe is made apparent by an old story of the way Agassiz began with students who came to him to study, although it was told to emphasize a different point. It was said that Agassiz took a fish from alcohol and asked the students to observe it and tell what they saw. After some hours he came back and asked what they had seen. Their report was very meager. Agassiz left them again with the single suggestion that they draw the fish. When he returned again after hours, the drawings were better than the reports, but were still not satisfactory. With a few questions he pointed out the essentials they had overlooked, and showed them how different the trained observer is from the untrained.

Questions Aid Observation.—The deduction that was made from the illustration used to be that one must learn to observe by observing. This we may accept. We would add to it, however, the statement that it is a waste of time to leave the beginner to unaided observation. He must from the beginning be given a definite set of questions, or, what is better, be given the materials

and a certain amount of knowledge, that will compel him to raise questions for himself and then observe to discover the answers to those questions. Science as a whole has advanced by having one problem suggest a number of different questions whose answer might be found by observation. Each answer given suggests a new problem which impels to new observations or new experiments. The difference between the trained and untrained observer consists in part in the fact that the trained observer always looks with certain questions already formulated. He finds the answer to those questions and so observes to good purpose.

The Project Method.—Recently two methods have developed which are based upon this principle that observation is effective only when it grows from a spontaneously felt need. One, the Montessori system, deals with young children and endeavors to make all learning a part of the child's play, and so lets the child's problems arise without formal setting of tasks. That means that there is the maximum attention to each object, although there may be long periods in which no object directly connected with education receives attention. The other method that makes insistence upon self-set tasks and consequent natural attention the aim of the teacher's art is the project method devised and advocated recently by various American teachers of education. In brief, the method consists in encouraging students to discover problems for themselves, and then to aid in finding the solution of their problems. It interests us here only so far as it makes use of the principle that adequate attention comes most readily from a definite task, which is most real when it arises spontaneously. It is directly

related to attention in connection with the teaching by observation. Indirectly it is a method that depends upon attracting attention, since reading, listening to addresses and all else are dependent upon that.

Applications and Objections to the Project Method.—In practice this method implies that the teacher must indirectly raise some problem which naturally interests the child, with which whatever is to be taught may be connected. Thus if one is to discuss digestion, the child must be led from interest in his own indigestion to ask questions about the various processes that may go wrong, and so to find for himself the answer to the many questions that arise naturally. This might involve reading, or in certain cases actual experiment. It would be almost certain to involve observation in each instance. The advantages of the method are numerous, especially in the greater effect that always attaches to the material thoroughly acquired through complete spontaneous attention, and material which is associated by natural bonds with many other facts. Every good teacher consciously or unconsciously makes use of the method. Attempts to restrict all teaching to the method, to induce the child to hit upon his problems for himself, frequently leads to the development of unnatural schemes, particularly at the hands of the less skillful teachers. These sacrifice the end to the method and should be avoided.

Education as a Condition of Attention.—Even more remote factors in the life history of the individual must be considered in a complete explanation of why the individual attends. We may group these in the statement that what shall be attended to and the effect-

iveness of attention depend in part upon the earlier experiences of the individual, what, in general, we call his education. The expertness of an individual in sense discrimination increases with practice, and the change may be ascribed to the series of conditions in the central nervous system which determine attention. The trained hunter or the Indian sees signs of game where the untrained even with better eyesight see nothing. They cannot see the signs at times after they have been pointed out to them. Expertness of tea and wine tasters, of individuals who judge the quality of fabrics, and skill in many other fields depends upon increased capacity of this kind. It makes the trained individual capable of seeing what the person untrained in the same line is not able to see.

Education Determines the Direction of Attention.— A second effort of education is to aid in controlling selection. An individual with one type of education or previous experience is likely to see one thing, an individual with another education will see something else in the same environment. Take a stranger into a factory or elsewhere where there are objects of many different kinds, and what he sees will give you a very good notion as to what his training has been. The engineer will, other things equal, see one set of objects, the sociologist another. At the end of a course in botany, the student will notice many things, both inside and outside of the laboratory, that he would not have noticed before. A large part of the benefit from any course consists in this increasing of the field of attention. Each object seen, each new fact acquired, prepares the individual to see something else, and thus widens the capacity of obtaining new knowledge.

Education Raises Questions.—The effect is to be explained in part by the provision of questions and attitudes mentioned above. An object seen arouses associates and these aid the entrance to consciousness of the corresponding objects. Thus to the student of botany, the sight of a flower may raise the question as to what class it belongs. This, in turn, will suggest counting the number of petals, which will give a bit of knowledge that would not have been received had earlier training not suggested the question. Education prepares the system of connected experiences, that makes the sight of one object slightly excite the parts of the nervous system that are to receive other impressions and so prepares the way for them. Were it not for the preliminary connection of these parts in groups, question, purpose, and attitude would not have their effect. In part, education seems to exert its effect more directly. Often no conscious question or problem intervenes. We see what education has prepared us to see without any preliminary idea that we are to see it. Any object that fits into the framework prepared by previous education impresses us at once.

Education and Attention as Apperception.—This effect of education upon attention and the memory processes that depend upon attention was the foundation stone of the first psychology of education under the name of *apperception*. Herbart, who developed this point of view, asserted that what was already in mind, decided what new impressions should enter. The earlier knowledge determines what new knowledge should be acquired. This effect of the experiences already acquired upon new experiences was used in two ways in

developing a theory of education. The first was that you should never attempt to teach a child anything that was not in some way related to what he already knew. This was the law of interest, that the child was or could be interested only in what he already knew something about. The second law, a corollary of this, was that if you had occasion to teach a child anything in which he was not interested at the time, you should seek to make it interesting for him by connecting it in some way with what he already knew. Both of these laws are closely connected with the fact we have been developing that what one shall attend to depends both for the adequacy of the knowledge and for the fact of attending at all upon the earlier education, in the broadest sense of the term. Which one will be selected will be determined by what the earlier education has been. The effectiveness of the observation will depend closely upon the character of that education, as will also the degree of interest that is aroused by what is perceived. All this was brought under the head of apperception, in so far as the facts had been developed when the term was in general use. In addition the term was used also to designate the fact which will be developed in the chapter on Perception that one always adds something from old experience to constitute the object that is seen. Apperception, however, has been applied by other men to many other processes, to the voluntary activities and others; so many different meanings have been given to it, in fact, that it has been spoiled for scientific purposes. We shall not attempt to make farther use of it.

Social Pressure as Determinant of Attention.—Most characteristic of attention as the assertion of the individ-

ual against outside forces is the fact that one will at times attend to something that is out of harmony with the immediate environment, even with the mental attitude that dominates at the moment, but which is enforced by some external authority. This is prominent in what we call voluntary attention, the attention that we force ourselves to make to unpleasant subjects by means of examinations and general discipline. When the student works for the attainment of these distant ends the incentive is still capable of being resolved into simple elements, and so given a causal explanation. The real force that holds one to tasks of this sort when others would be much pleasanter, is to be found in the social instincts which were discussed in Chapter V. The approval of the social group, near and remote, is probably the strongest influence in the life of a man. When a student attends to a lesson because he must pass an examination, the real reason is to be found in the enjoyment that comes to him from the approval of teachers and fellow students, or, more immediately, from the displeasure that he receives from their disapproval. Where the student is not interested in marks, if such cases exist, but works only for the good that the subject is to do him in his chosen profession or work, the driving force is none the less social pressure. The approval that impels him is that which he is to have from the world at large, and from immediate family and friends as he succeeds in later life. His profession has been chosen because it is respected by the world or that part of it which he knows, his courses are chosen because the authorities of the school believe that they are adapted to make him expert in that profession, and he strives to do well in them be-

cause they help him towards that end. The forces that impel him, when he seems to be most spontaneous, are social and so far external.

Instinct and Attention.—Finally the boy attends because of more immediate instincts. Probably he attends to moving objects because of instincts. Did the race fail to attend it would not survive. The boy attends to members of the opposite sex, to a fight, to works of art that represent the human form or anything resembling it, all because of instinct. This means, nervously, of course, merely that the sensory areas in his brain are particularly sensitive to certain stimuli. When these present themselves they are sure to have an effect and by adjusting his movements to them, the individual increases his chances of surviving and of continuing the race. If we keep our different influences in terms of our original formula, that attention is an expression of the previous history of the individual, instincts are the result of the experiences to which the race had been subjected before the individual life began.

Summary.—Altogether, then, if asked why a boy or man attends as he does, the answer is to be given that he attends because he has the nervous system that he has by inheritance, and because of the stimuli that are affecting him at the moment. His nervous system at the moment is the result of the slow progress of evolution that has left its traces upon him in certain instinctive tendencies to receive one general class of stimuli rather than others. It is also modified by the effects of the influences that act upon the individual after birth, by the immediately preceding experiences, the idea in mind, the question that has been asked just before, the attitude

or purpose, and back of this by his general education, and the ideals that he has derived from the society in which he lives and which that society enforces by the instinctive pleasure which he feels at its approval and the suffering that afflicts him when it disapproves of him. Attention is not an isolated fact, but the expression of all of the influences that have worked upon him since birth, and of his nature at birth as well.

Attention and Ideas.—It must be insisted, too, that all of the forces which act in determining what object shall be seen, also aid in selecting the returning ideas that shall present themselves in imagination and in memory. The mental life is a mixture of material from two different sources. The one we have been considering comes mainly from the senses. Alternating and mixing with this we also have the memory elements. These were at their first appearance sensations which left their impressions upon the nervous system, and later recur as a result of the associations that were formed at the moment of entering. In many cases memories and imaginings compete with sensations for the control or domination of consciousness. At such moments, whether one shall see or recall depends upon the attitude, upon the conditions of attention as we have outlined them for sensation above. Attention, too, determines whether one or the other of two ideas, each offered by a different association or connection with the idea dominant a moment before, shall enter the mind. Particularly important in this control of ideas is the purpose or mental attitude. If a word is shown when one is trying to solve a problem of one sort, one word will be recalled; if the problem is different another will be

thought of. If you show two numbers one under the other as $\frac{9}{7}$ with the request to subtract, 2 is at once thought of; if the request is to multiply, 63 is evoked just as quickly; if to add, 16. What changes is the mental setting or purpose. Most control of thought is of a similar kind. The recall of ideas is guided by the same factors that determine attention.

Interest and Attention.—After the list is finished we seem not to have touched upon the problem of the rela-

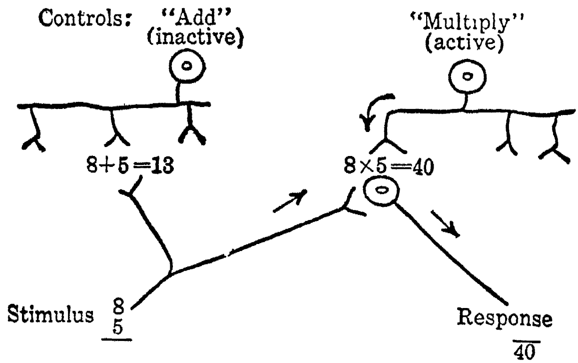

FIG. 10.—Control of association. The $\frac{8}{5}$ combination has been associated with 40 = 8×5 and 13 = 8+5. Here the conditions or directions make the multiply connection active, so that synapse is crossed and 40 is thought and spoken. (Woodworth, "Psychology.")

tion of interest and effort to attention. If one should ask any non-psychological individual why he attends, one would be pretty sure to receive the answer that he attended because he was interested or that he attended because of the effort he was exerting. If the conditions of attention as outlined above are complete, these should have been covered already, if not we should extend them to include these factors. Interest has two relations to attention, in fact the term interest is used in two differ-

ent senses. In the one, it designates a condition of attention. We say that we attend to a story because it is interesting. If we look a little more closely, it appears that it is not the story that is interesting, but that the individual is of a character to be interested, and and so to attend. The story need not appeal to all. Interests differ from individual to individual, and in the same individual from time to time. Interests vary with the education, with the mental attitude, while certain are common to all because of the fact that all have the same instincts. In fact there is complete overlapping between the objects that we attend to because of instinct, education, and mental attitude and the objects that we call interesting. In this sense we may say that interest is a popular name for attention from instinct, education, and mental attitude.

Interest also designates the feeling of pleasure that results from attending. Attending of any kind and to any object induces a feeling of pleasure, and the more completely one is absorbed in the process the greater is the pleasure. When one describes the experience later, one says that one has been interested, or that the thing attended to was very interesting. This is not the cause of attending, but the result. The fact that the word "interest" is used in two senses as distinct from each other as cause and effect indicates that one cannot regard it as a single process, that can be taken without farther discussion as the cause of attending. It is truer to say that interest is a word that is applied popularly to different phases of one form of attention, the form that is induced by instinct, education, or attitude and is accompanied by the feeling of pleasure. This is

usually designated by the psychologist as the non-voluntary form of attention since it is the type that requires no voluntary effort, and at the same time is accepted.

Effort and Voluntary Attention.—Much the same statement may be made of the relation of effort to attention. It, too, is used to designate one cause of attention as well as to indicate one of the mental accompaniments. As cause of attention we use effort to describe what seems to be an especially strong exertion of the self. When the student studies a lesson because he feels that he must have it the next day when he would much rather be on the football field or reading a novel, we say that it is the effort that he exerts which holds him to the work. Look a little more closely and we find that the form of attention described as effortful, is the attention which is directed to remote rather than to immediate ends, and to ends that are enforced by social pressure. This ultimately goes back to the fact that man is driven by instinct to do that which the group that he accepts as his own expects him to do or approves. He is much pleased with himself when he feels their approval and is greatly pained when he feels their disapproval. In short we apply the term effort to the social instincts which drive an individual to do that which is at least at the time unpleasant.

Effort as Sensation of Strain.—Effort attaches more directly in the popular mind to the feelings of strain that accompany attention determined by these social instincts. When there is conflict between the immediate and remote desires, the muscles of the face and hands, and to a lesser extent the muscles of all parts of the body,

become rigid. The contraction stimulates sensory ends in the different muscles, which give rise to the sensations of strain. The mass of sensations together constitute the feeling of effort. We believe when we feel these contractions that we are doing more than usual. They have come to be regarded as a sign of effort, and we tend in our popular thinking to reverse the natural order and think of the effort which is only the sign as the real cause of the action that results.

Effort and Efficiency.—That the muscular contractions which constitute the source of the sensations are not the cause of the attending is obvious from the fact that attention is usually not more effective when they are most pronounced. They are most prominent when one first turns to a task, or when one is working against a distraction. After one warms up to the task and is really working most effectively, the contractions disappear and with them the feeling of effort. Experiments comparing the efficiency of individuals in various tasks when they were working naturally and with effort showed that they were more effective when working without effort. As we shall see, when distraction is introduced strains begin, but these, too, seem to be but an outward sign of increased endeavor; they are not themselves the cause of increased efficiency or an immediate sign of the activity of hidden forces. If one puts the events in their natural series, it seems that when an obstacle is met, the social instincts cause the individual to respond more vigorously with the nervous system as a whole. Part of this response is motor, although the motor part is largely useless, a mere association between the necessary activity of the sensory phases of the activity

and the motor. We become aware of the motor through the sensory nerves in the consciousness of effort and have come to regard that consciousness as the cause of the activity. The real cause is the group of social instincts. This form of attention is ascribed to the will, and opposed to the other as voluntary attention.

Distraction and Attention.—A problem much investigated that has a bearing upon the nature of effort as well as upon practical problems concerns the effect of distraction. Distraction was first studied in an effort to measure the efficiency of attention, on the assumption that the amount of distraction required to render attention impossible would indicate the strength of attention. The experiments gave the apparently paradoxical result that, many times, attention was more effective with distraction than without. More careful experiments indicate that the very first change when a distraction is introduced is to cause a decrease in the amount of work accomplished. This is followed by an increase. Whether the net result is an increase or a decrease depends upon the length of the interval during which the distraction lasts. Experiments in which records were made of the breathing and of the pressure exerted in recording the results showed that when distraction begins in the midst of a long piece of continuous work, many motor contractions are increased in amount, the results are spoken half-aloud, *e. g.* The immediate effect of the distraction is to spur the nervous system to greater activity, and this greater activity is more than sufficient to counteract any injurious effects of fatigue. This greater activity shows itself in increased motor overflows, of which some induce useful movements; others are

useless or even positively harmful. After the distraction is removed there is ordinarily a decrease in the activity of the individual as a whole that makes the work even less effective, less accurate and less rapid than before the distraction was introduced.

Explanation of Distraction.—The effect of distraction is to be explained in part by the fact that any stimulation tends to increase the excitability of all parts of the nervous system, without reference to the part that is first affected. In part, it is due to the natural stimulus of difficulty or failure to increase the activity of the parts of the nervous system directly involved. If the distracting stimulus becomes too strong, the work accomplished is decreased. There is a limit beyond which the compensation of increased activity no longer suffices to overcome the deleterious effects of the distraction. From the practical side, it might be argued that these results of distraction experiments prove that a noisy study room is better than a quiet one, that the distraction actually increases the effectiveness of study. This deduction overlooks the fact that distraction always increases the fatigue and probably finally decreases the total amount of work that can be done. It may make distraction useful as a temporary spur on the principle of whipping a horse at a critical place.

The Conditions of Attention and Educational Theory.—The theories of education in general have been much influenced by notions of the conditions that influence attention, and may be considered briefly in this connection. The Herbartian pedagogy, which dominated the world's educational theory for two generations and still has its effects under different names, argued that

nothing should be taught the child that was not interesting to him. A saner interpretation would restrict the rule to mean that all that is taught should be in some way connected with what he already knows; for what is interesting, we have seen, is determined by the individual's previous knowledge, by his momentary attitude, and by his instincts. Were one to limit what should be taught to the interesting, it would make possible little advance in knowledge, while if one decides what should be taught on the basis of social needs one may still find a way to make that necessary knowledge interesting by connecting it up with what is known, with the recognized purposes of the child and his dominant attitudes.

The Content of a Course Determined by Social Needs, not the Child's Interests.—On the other hand, it is equally undesirable to subject the child to the demands of the opposite theory, that he should be trained to do what he dislikes for the sake of discipline. This theory is based on the assumption that the child may form a good character by forming a habit of doing what he does not like. It dominated the education of half a century ago, but has gradually been abandoned, in part a result of the growth of Herbartianism. It is doubtful whether a habit of this type will transfer, and in any case there is not sufficient gain for the students who succeed and remain to make up for those who are driven from school or are discouraged by the method. On the whole we may compromise the conflict between those who insist upon education through the non-voluntary and those who insist upon education through voluntary attention alone, by insisting that what shall be taught should be determined by the needs of society, while the teacher

should find some means of relating this material to what the child already knows and with his dominant purposes in such a way as to make it interesting. Where there is no such connection, it is better to insist that the child learn what is essential by definite effort, evoked by appeal to social ideals, than to permit the student to pass through the schools without obtaining that knowledge. In any curriculum there will be enough uninteresting material and sufficient points of difficulty in the most interesting subject to provide all the discipline that is needed.

QUESTIONS ON CHAPTER VIII

1. How many of the sensory impressions playing on you at this moment really become conscious?
2. How long can you attend? Watch yourself for ten seconds and count the number of different ideas and objects or phases of objects you become aware of in the time.
3. Add a column of ten two-place figures first when doing nothing else and record the time. Then add another column of the same length and difficulty while you repeat half the states with their capitals. Then take the time for repeating the states and capitals while doing nothing. Is the time required for doing both equal to the sum of the times for the two?
4. Why do you feel strained when you attend?
5. How can you tell when a child is attentive?
6. To what is the child likely to attend?
7. Can you change the interests of a child?
8. Can you teach observation in general?
9. What justification exists for the project method in the light of the influence of purpose on attention?
10. Compare the older doctrine of apperception with attention as the expression of purpose.
11. How does one select an idea?
12. How are interest and attention related?
13. What does effort contribute to attention? From what does effort arise?

14. How does distraction influence attending? Should distraction be avoided?

REFERENCES FOR CHAPTER VIII

PILLSBURY: *Attention.*
RIBOT: *The Psychology of Attention.*
CHARTERS: *The Project Method.*
EARHART: *The Art of Study.*

CHAPTER IX

THE LAWS OF LEARNING, AND THE ART OF STUDY

The psychologist has perhaps more to say concerning the best methods of studying than about any of the other functions of the teaching and learning process. Much of his material has been developed by experiments under laboratory conditions upon rote learning, but many of the results can be transferred with little change to the learning of the student, young or old, under the conditions usually applied in the schoolroom. In some cases actual experiments have been made on school material and even under school conditions. Here the inference from the laboratory results to school practice is more direct and the conclusions are to be trusted in every sense.

The Nervous Basis of Recall.—The nervous processes involved in memory are the same as those in habit discussed in the last chapter. As we think of the learning and recall processes to-day, they are simply the inducing of changes in the synapses of certain parts of the nervous system, changes which persist indefinitely and which may be rearoused for a long time after the original event. When one sees an airplane for the first time, the impression from the optic nerve is carried to the posterior portion of the cortex, and there passes through chains of neurones until it reaches the frontal area where

it may arouse the exclamation "O!" or "See there!" to a companion. If it were a habit only that we considered, each time an airplane were seen one would expect the same response. That may or may not happen. What does happen is that there are other neurones aroused by the first, sensory as well as motor, and when these are stimulated the synapses between them and other neurones excited at the same time become more readily crossed. When now, any one of the neurones active at that time is excited again the whole mass of sensory and probably some of the motor neurones are also called into action with them. The whole neural complex is reinstated.

To the action of these sensory neurones, there corresponds what we call the consciousness of the event. When the original impression is made, we are not at all aware of the chemical changes that take place in the neurones or directly of the passage of the impulse across the synapses, but we do have a picture of the event. We are aware of the airplane, and of the remarks that we make and hear about it. Why the chemical activity of certain neurones should be accompanied by the picture, we do not know and need not speculate about in this connection. Certain it is that when a group of sensory neurones in the cortex is affected in this way we have the picture. What interests us is that the picture occurs and also that whenever the same kind of activity spreads through the same neurones again, we see the same picture. Memory, then, is merely the repetition of the action of the cortex when the original stimulus is not present. Some stimulus which was connected directly or indirectly with the neurones active at the time replaces

the original stimulus. Habit and memory are fundamentally one.

Retention as Perseveration.—Assuming these as the basic principles we must make a few definitions of the terms involved and attempt to reduce the process to the simplest laws. There are two senses in which the term memory may be used, and two simplest principles which are involved in all memory. The first is a mere persistence of the original activity, what has been called recently the "perseverance tendency" or "perseveration." Whenever any nervous action starts, it takes some time for it to reach its maximum; it lasts about as long as the external stimulus and then dies out very gradually. One can see this best, perhaps, in the visual after-image. Whirl a stick with a glowing spark upon it in the dark and the path of the spark is seen. It is as if past and present position were photographed and made simultaneous. That is really what happens. The retina responds somewhat slowly to the stimulation, but when the stimulation is once established, it persists for several tenths of a second with gradually decreasing intensity.

The same holds of the cells of the central cortex. If you will look out of the window for an instant and then look away you will see quite clearly for two or three seconds the objects at which you looked. You will see them so clearly, in fact, that you can describe them just as well as if you were still looking. This is not due to the persistence of the stimulation on the retina as is the image of the spark, but to persistence of the stimulation of the cortical neurones. You can convince yourself that it is not an after-image on the retina by moving the eyes. An after-image moves with the eyes, these

persisting memory after-images remain in the same place whether you move the eyes or not, or if they seem to move, they move as you desire even if the eyes are at rest. As we shall have occasion to see later, these impressions die out rather gradually and probably persist as latent dispositions to activity in the nervous system after they have ceased to influence consciousness. This is sometimes known also as primary memory or as perseveration. Perseveration is used rather of the whole latent disposition; the other terms are used of the explicit images.

Association in Memory.—The second type of activity involved in what we know as memory is retention and recall through association. Nervously, retention is due to the persistence of the connections at the synapse between different groups of neurones; recall to a rearousal by means of these connections of one group by another. As the fundamental law here we find the fact that when two neurones or neurone groups are active at the same time, there is established a connection between them at the synapses, of such a character, that whenever one of the two is excited again there is a tendency for the second to be aroused also. The law is the more interesting, because it holds no matter how far removed the two parts of the cortex may be that are originally aroused. It may be two parts of the same sensory area, as two visual impressions, but the law holds just as completely when the areas are as far apart as the auditory and visual areas. When the child sees a word and hears it pronounced, the connection is established between them, if they are often enough repeated, just as certainly as when they are side by side and parts of the same sensory

area. It has been suggested that there is some kind of drainage from one into the other that opens the synapses, by the passage of the impulse from each to the other. This is only an imaginary picture. Still, aside from the fact that the discharges that connect them last only a short time, the picture may represent very well what happens. Certain it is that when two sets of nerve elements are excited at the same time there is a tendency for each to arouse the other, so that on the drainage hypothesis each must drain into the other.

Learning a Change in the Nervous System.—Assuming this fact, learning is nothing more than the formation of the connection at the synapses of the sensory neurones involved in the two sensory processes. Retention is just the persistence of this connection once it has been established, and recall merely the reëxcitation of one of the elements at the time some other of the elements is excited again. The problem of learning for the student and the aim to be attained by the teacher is to accomplish the formation of these paths in a way that shall give the maximum of retention with the minimum of effort and time at the moment of learning. Experiments on learning have been made with reference to two forms of learning: one, the learning that depends upon direct observation of objects and events, such as when a witness observes an accident that he may describe on the stand; the other, the learning of symbols, words or phrases, as in the mastering of the material in a book in preparation for a lesson. The two differ in that the first provides the actual raw material which may be put into words or other more rational or conceptual forms.

Observational Memory.—The learning of the ob-

servational type is subject to three kinds of errors or conditions, one set that acts, at the moment of exposure, or of presentation, a second in the changes that take place in the individual between exposure and the time of recall, and the third dependent upon the conditions under which the recall is made. Experiments have been made by asking the children or other observers to look for a brief time, say twenty seconds, at a group of objects or a picture and then, after the lapse of a definite interval, to report on what was seen. What is seen, obviously, is determined by the conditions of attention. These are twofold in character: permanent conditions, due to heredity or training which act at all times alike, and the temporary conditions which vary from moment to moment. Of the former it is found that all are most likely to observe people and objects, less likely to note space relations, then numbers, and last of all, color. With children, little but people and objects are noticed. As the individual grows older, more of the other characters of a picture or real scene will be observed by him. A child is very unlikely to notice the color of an object and so cannot report upon it when asked later. Even in an adult, it is not necessarily a sign that he is testifying falsely on the witness stand if he makes a gross mistake in naming the color of an object or even of many objects in a scene. He may be accurate as to objects and inaccurate as to colors and numbers.

Observation is of What Corresponds to Questions.— The temporary conditions of observation are mostly found in the questions that the observers ask themselves as they look. If there are no questions, little will be seen. Where the individual looks to obtain an answer

to a definite question he will find the answer to that, but may see nothing else. What questions will be in mind at first depend on chance suggestions. They increase and become more appropriate with practice in each situation. This is important in all teaching by the natural observation methods. It is practically useless to present a child with a bit of material of any kind and leave him unaided to find out the essential details. He will spend a long time finding something to look for and then will probably have the wrong question in mind, so that while he obtains the answer to that, he will not be able to answer any of your questions on anything else.

In nature study you must either put questions definitely to the child concerning the objects and phases of objects that you want him to see or at least give him some cue that he may use in developing questions or problems for himself. To leave him unguided in this connection is a waste of his time and is likely to be a waste of your time also. A large part of the training in observation as seen in these experiments is in learning what to look for in any given setting. A second time one will look for what one failed to see at the first, and with sufficient training one will know what to ask one's self in any situation and so will see all that is adequate to the problem in hand. After practice, when the situations become familiar, one will see without being conscious in advance of what to look for. The observation will become almost as unconscious as a reflex. Even then, only the things that seem essential will be noticed by the student. He may be an excellent observer in general and not be able to say what the design upon the

wall paper of his study is, in spite of the numerous times he has looked at it.

Errors Due to Additions Through False Associates.—A second fact of importance at the time of observation is that the individual is very likely to add to what he sees other things that are ordinarily seen in connection with them, whether they are really present or not. It is this supplementing by the laws of association that leads the individual, even when asked to report at once, to say that he saw things that were not present, but which are usually present in that setting. Thus in an experiment in a German seminary, a scene was enacted before a group of students, who had not been told what was to happen, in which one man threatened another in words and waved his hand with a bright paper cutter in it toward the individual. In the report several observers said that they saw him point a revolver. The general setting and the position of the hand suggested revolver and revolver was seen.

Increase of Errors with Lapse of Time.—Of the changes that affect the accuracy of the report between the presentation and the report, the most important is the time elapsed. It has been found that the rate of forgetting for observation like the forgetting of nonsense syllables, as will be seen later, is very rapid at first, then more gradual; about the same amount is forgotten during the first five days as in the next ten or from the fifteenth to the forty-fifth. This forgetting is slower when the material has been put into words than when an attempt is made to retain the image alone. Thus, if a man counts the number of windows in a house and remembers the number, it will be approximately ac-

curate; if he can remember only how the house looked and then attempts to count the windows when he recalls the image, he will be very uncertain. The error grows with the time that elapses, while when they are counted and the number is what is held in mind there will be only a slight increase in the percentage of mistakes.

Errors that Arise at Time of Recall.—The factors that determine the errors at the time of recall are the associates that are added to the material actually seen. Additions are more likely to be made at this time than at the time of the presentation, because there is little chance to check up to see whether the added element is really present or is merely imagined. A second related factor in determining the mistakes is the degree of suggestion that is exerted by questions at the time of report. There are obviously two ways of taking the report. One is to ask the subject to say what he saw in the picture when it was shown him and give him no other indication of what may be wanted; the other is to ask him whether he saw this or that of the objects that were present. The former method always gives a more accurate report, although it is also less rich in detail.

Accuracy vs. Range in Recall.—We may oppose accuracy and range here. We measure accuracy by the percentage of objects reported correctly to the total number of objects reported. Range is measured by the percentage of objects seen to those actually shown. Using these terms, we find that free report gives an accuracy of from 85% to 95% and a range of 50–60%, while the deposition in answer to questions will have an accuracy of 60–70% and a range of 80–90%. Where the questions are leading, the number of mistakes will be much in-

creased. If one puts the question in the most suggestive form, which is that which implies something that is not in the picture, it will mislead in more than half the cases. Thus if I ask the color of the beard of a man who has no beard, many, even of university students, will assume he had a beard and name a color. The reason that the question leads to error even when it is as little misleading as possible is that many events which are forgotten or barely remembered will be wrongly supplied. Without intending it the individual will guess concerning what he did not see and will believe that he actually saw it. The influence of the question is particularly misleading with children, and the younger they are the greater is the effect. Questions should be used only sparingly in obtaining evidence from children, and even in the schoolroom, they should be used with the greatest possible care.

Words vs. Imagery in Recall.—In terms of the mechanism of recall the events or objects presented are in part retained by mere perseveration. This holds them for a time. Both during the period of presentation and during the memory after-image that follows for a few seconds, there is a process of translating the images into words. Only the more prominent elements and those that correspond to the question in mind will be translated in this way. At the time of report, some request of the experimenter suggests the question, by association. This calls up the event as a whole and this the series of ideas that were put into words, or the words into which they were put. All the time there is a background of vague picture against which the questions appear. Some of the matter reported upon is supplied by the mere image

itself. These are the less certain elements. Most comes from associations actually formed with words at the moment of presentation. As questions are asked, more and more will be supplied from the picture and in consequence the number of mistakes made will constantly increase. In general it will be seen that ability to report depends upon the certainty with which associations have been formed between the cue that suggests recall of the material in the experiment and the things that were seen at the time of exposure. Concretely recall is determined by the associations between the different questions that are asked and the objects that were seen by the individual during the period of exposure.

Verbal Memory

Memory for Symbols and Language.—Very similar in many ways, yet very different in others, are the laws that determine the recall of ordinary school material as presented in the books and lessons of the schoolroom. These laws were among the first to be investigated in experiments on memory. The materials used were nonsense syllables. These are combinations of two consonants and a vowel made systematically by all possible arrangements. After all have been gathered together those are eliminated that constitute words in the language used by the observers. From these, series are then chosen by lot, and these are learned purely mechanically. Two methods are used in testing the accuracy or completeness of learning. One is the method of relearning, or the savings method. The number of repetitions required for the first learning is determined, then after different intervals the material is relearned

and the number of times required for relearning is subtracted from the number of repetitions required for the original learning. This gives the saving or the amount retained. The percentage of this to the number required for the original learning serves as a measure of the accuracy of the original learning, or of the amount forgotten in a given time. This measures the potential, not the actual, memory. The other method measures the amount of the retained material which is actually effective for the individual at the moment. In this the syllables are learned in pairs and for the test one of the pairs is shown and the observer asked to supply the other. The measure is the percentage of accuracy of this supplementation. The two methods it will be seen measure different things. The amount retained, in the first method, may not be at the command of the learner at all, he will never know that he has it unless he relearns. The other measures the knowledge that is immediately at command.

Of the laws of learning we shall notice here only those that are actually made use of or may be directly applied to the practical school work, or to work of any kind that involves recall. For convenience we may follow psychological usage and divide our discussion into three parts, the laws of learning, the laws of forgetting, and the laws of recall.

LEARNING

Laws of Learning.—Learning depends primarily upon the number of repetitions made. Apparently within relatively wide limits, the greater the number of repetitions, the longer and more accurate is the retention.

Less mechanical is the effect of attention. Reading with close attention is much more accurate than reading with less attention. We should do our best to keep attention regularly applied all of the time. Similarly the more meaning a bit of material has for us the easier is it to learn it. This again we keep constant by learning nonsense syllables which have no meaning.

Law of Divided Repetitions.—A law that is directly applicable to school work is that it is much better to divide repetitions over several days than to learn all at once. If a man has a set of twelve nonsense syllables to learn and has twelve repetitions to give to them, he will learn much more of them if he will recite them through once every other day than he will if he repeats them the twelve times all at one sitting. Any division is better than this complete accumulation. If the repetitions are separated by more than three days the effect of division is not so good. This law holds not merely for nonsense material. Mrs. Austin has shown that sense material learned as one ordinarily does merely for the ideas, is also learned more readily and retained better if it is read once a day for five days than when it is read five times in one day or twice one day and three times another. She also found that with sense material, the beneficial effects of dividing repetitions were much more evident when the learning was tested after longer intervals. In her experiments it was found that if the material is to be tested after only twenty-four hours, it matters little whether the readings are all on one day or divided, but if they are tested after two weeks about twice as much will be remembered when they are divided as when they are made all on one day.

Explanations of the Law of Divided Repetitions.— The explanation that seems most adequate for this fact is that the results of the repetitions continue to be effective for the formation of associations after the reading has ceased, during the process that we called perseveration. If the repetitions are made all at one sitting, there is only one dying away of the original excitation and only one prolongation of the period of formation of associations or of "setting." Whereas, if there are five repetitions on separate days, there will be five periods of perseveration. Perseveration will be added five times to the effect of the actual period of repetition. The material will be much better retained. If these setting periods come too far apart the effects of the first repetition will be too far obliterated to be readily renewed, but if they are less than three days apart, the effect will be favorable.

Reviews should be Frequent.—The practical advantages of this law are numerous and obvious. Directly, it means that more will be accomplished with the same time when the material is repeated a number of times than when it is dealt with more thoroughly once and not referred to again. Reviewing, if the reviews do not come too far apart, is extremely effective in fixing the material to be learned. Edwards has shown that the same amount of time may be much more effectively used by giving part to the first lesson and part to two brief reviews than by devoting all of the time to a more thorough first study. In the preparation of a lesson it follows from this, too, that one can to advantage read a lesson once one day, then again the next day and on successive days. Even if it is not completely fixed when it is left, it will be an advantage to drop it and read it

again the next day. Beginning some time in advance in the preparation of a lesson and spreading the preparation over several days has an advantage. This may justify, too, distributing the recitations in a course over the week with a day intervening rather than to have them each day in the same subject. This is certainly true if the student will distribute his study and if the material of the lesson is repeated or reviewed in different recitations.

Cramming.—The explanation of the advantages and disadvantages of the old problem of cramming can be found in these results. If material is learned all at one sitting, as just before an examination, it will be retained fairly well for twenty-four hours, but will be forgotten as soon as the examination is over or shortly thereafter. While if material is learned throughout the semester, and reviewed from time to time and then reviewed again for the examination, one has the distributed repetitions of the experiment, and obtains the advantages of greater permanence of retention. To be able to cram on occasion as in the learning of a part by the actor, or the study of some subject which the lawyer needs for a case and may never need again, is highly desirable, but material learned in that way is sure to be as quickly forgotten as learned. The work of a school which is supposed to be remembered for a long time,—for life, if possible,—must be learned by distributed repetitions.

Learning as a Whole vs. Learning by Parts.—Another rule that may be applied whenever any material is to be learned by rote, probably still more when material is learned for the sense alone, is the law that it is better to learn as a whole than to learn part by part. This was first demonstrated by Miss Steffens. She

found that in learning poetry a considerable saving was made if the learner would read the whole each time as compared with the natural method of learning a part at a time, a line or a stanza alone. Later experiments by Meumann and a student show that from twenty to even sixty per cent of the time may be saved by reading as a whole. They found, too, that the method of reading a small bit at a time was probably adopted from the desire to make sure that something was being accomplished, that some part was really being learned, for when one merely keeps on reading there is no assurance of attainment,—no feeling that anything is saved as a result of all of the work. To gain something of the same effect, Meumann recommends that when the subject becomes bored or tired, he should stop for a brief period and then read on again without going back. If this is not done the reading is likely to become slow, and time will be lost even if the repetitions are fewer.

Why Learning as a Whole is Better.—The explanation of the saving through reading as a whole is that time is lost in the part method by repeating the first lines or stanzas more frequently than is necessary to learn. One goes back to read the beginning each time to attach the new to the old and thus spends more time on the first than is necessary. Then each time the reader goes back to the first of a line he tends to connect that with the end of the line below, an association which should not be formed and which when it is formed tends also to prevent the formation of the correct association between the end of that line and the beginning of the line following. This is what we call an associative inhibition. Then, too, there is probably something in keeping atten-

tion and meaning running on together. Attention goes uninterruptedly from beginning to end in the whole method, while it is much broken up in the part method.

Objections Considered.—One might ask if there was no limit to the length of selection that should be learned by the whole method. Pyle found that the law held for a length of material that required fifty minutes to be read through. That is as much as one ever has occasion to learn by rote, and there is no reason to assume any limit. If one complains that one would not have time to learn so long a selection at one sitting, we need do no more than to point to the last law, that it is an advantage to wait twenty-four hours or more between repetitions. It is found in practice with oratorical selections that if one has something to commit to memory, if one will read it over as a whole once a day it will be learned without particular effort, as one student put it "without ever noticing that one is working on it." There is apparently an exception to the law in mechanical learning. It has been found that learning a part at a time may give better results for animals learning mazes, and even for men in certain types of motor learning.

The Greater the Rapidity of Reading, the Quicker the Learning.—Another law is that one should read as rapidly as one conveniently can, but without any great sense of effort. This of course saves time, but what is not so obvious, it saves repetitions. This is probably because when one reads more slowly one is likely to become inattentive. In practice, when a student feels that he has plenty of time to get a lesson and will try to read it slowly, which to many of us seems synonymous with carefully, he spends a part of his time daydream-

ing. When he is given a limited time for a lesson, as when he has neglected it the night before for a social engagement, he is all alert and every minute is one of fixed attention. Meumann suggests as a result of his experiments that one should read rather more slowly at first and later when the material becomes more familiar, should read more rapidly,—this is the natural tendency and is justified by test.

Frequent Attempts to Repeat Shorten the Time.—A fourth rule is that one should intersperse attempts at repetition with readings. Skaggs found it most effective to read twice and attempt to repeat twice. The advantage is that one is more active when attempting to repeat, and in consequence the associations are more quickly and certainly formed. The later readings are also looked forward to with interest as confirming or negating the attempted repetitions. In consequence attention is kept at the full for the entire period. Still another rule is that one learns most quickly if one reads with the intention of learning. Sanford illustrated this most completely on the negative side by his discovery, that in spite of a daily repetition of the morning service he could say through only brief parts that he had at some time intentionally committed. This was true although he estimated that he had read the service five thousand times before he made the test. One per cent, at the most, of this number of repetitions with the intention of learning should have been effective.

RETENTION AND FORGETTING

The Curve of Forgetting.—The laws of forgetting are rather fewer than the laws of learning. The first is the

merely physiological law of the course of forgetting. In general it is found that forgetting is relatively rapid over the first three days and becomes slower and slower as time goes on. Ebbinghaus found, using nonsense syllables, that one forgot about forty per cent the first hour and nearly sixty per cent the first twenty-four hours. Between three days and two months the amount

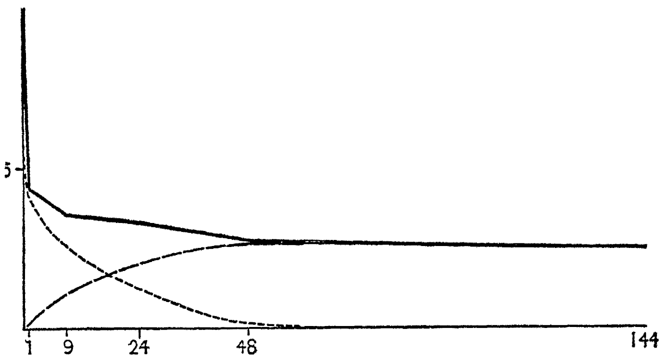

FIG. 11.—Analysis of the curve of forgetting to show possible co-operation of perseveration and association The full line shows the course of forgetting after Ebbinghaus, the dotted line the conjectured decrease in the primary memory (perseveration) and the dashes the initial increase in the strength of association due to perseveration.

forgotten increased only from about seventy to nearly eighty per cent. The twenty per cent retained was forgotten very slowly indeed. It should be said, however, that with these nonsense syllables it might very well be that at the end of two months not a single one of them could be remembered without prompting. The fact that there was retention could be demonstrated only by the ease with which they could be relearned, by the fact that there was a saving over the time required to learn them in the first place.

Forgetting is due to Reduction of Two Processes.—The explanation of the quick forgetting at first and the slow forgetting later is probably to be found in the combination in memory of the two processes of perseveration and association. The perseveration process disappears very rapidly, and is probably all gone in three days. The associations form somewhat slowly all during the period of the disappearance of the perseveration process, but they also disappear somewhat slowly, and when the repetitions have been frequent enough, or the attention keen enough it may be that the associations will last almost all of the life of the learner. It is interesting and of some practical importance in school work to note that there may be an effect of learning which is not revealed through the possibility of immediate recall. Much that a child learns is of value only in that it will make learning the same thing easier for him when he must learn it at a later period. These residual memories may and probably do modify his reactions to various things in other connections. They serve to control his judgments upon all topics, and to control his feelings and acts, even when he has forgotten that he knew them. This may be one justification of the common belief that an education has value even beyond the effects of the immediately useful knowledge.

Retroactive Inhibition.—This course of forgetting is not at the control of teacher or student. It is a mere physiological fact and necessity. Not much can be done to modify the retention. One can and does repeat from time to time particular facts that one has immediate prospect of requiring. This is really relearning or refreshing old and departing knowledge. One precaution

that is of value in certain cases may be mentioned,—this is to avoid any new work of great interest, and any excitement for a few minutes after learning has been completed. A fact, called by Müller retroactive inhibition, that has been noticed at times has a bearing upon this. If one turns immediately after learning one thing to learning something else, it has been shown by Müller that one retains less of the matter than one will if one permits one's self to keep a passive mood for a brief period, not more than six minutes. It should be said that not all investigators have been able to demonstrate this. It has been suggested that retroactive inhibition is more in evidence, is of greater degree, when one is fatigued or for some other reason in a poorer state of health or strength, than in the better periods when more rested. That it is a real phenomenon under sufficient shock is seen in cases of accident in which the memory of the events just following the accident will be forgotten later. This holds usually of bodily accidents, particularly blows upon the head which result in unconsciousness, but it also holds where no injury or only slight injury is suffered, but there is a scare or other emotional disturbance. There is probably sufficient evidence for the existence of retroactive inhibitions to justify resting for a few minutes between lessons, or after the completion of other bits of learning. The difference is so slight that it may well be neglected in emergencies.

RECALL

Recall due to Association.—Only a few things can be done to influence recall. For the most part recall is altogether beyond our control. It is dependent upon

the associations that were established at the moment of learning. If one has established a connection between a given stimulus or event and a bit of knowledge that would be desirable at the moment, one recalls and the situation is met. If the association has not been established, the knowledge even if possessed is not aroused and for the individual it is as if it had never been known. All that can be done to favor recall is to learn each bit of knowledge in connection with the occasions on which it will be needed later. In this one must be guided by the experience of others, except in so far as one should try to learn everything in as many connections as possible.

Attitude Determines Recall.—The other aid to recall is to have an attitude that is suitable to the situation, to see it in its appropriate settings. But this again is not a matter of control, it is apparently an innate quality and is a large element in what we call intelligence. You can teach the unintelligent man many things, but if he is really unintelligent he will recall them only in the connections in which they were learned,—there is no transfer to other situations. The intelligent man, on the contrary, will recall what is learned, in that connection, but also in connection with other occasions in which it might be useful. This apparently cannot be taught, it may possibly be improved by practice or confidence. What we do probably is to select the man who can make these transfers quickly and put him in places of responsibility, while the other man is gradually eliminated from school and so from the higher professions and positions.

Associative Inhibition.—One fact that may influence recall, and may be noted even though it cannot be con-

trolled is the interference that takes place between two or more associations with the same thing, both at the moment of learning and at the time of recall or of attempted recall. These again we call inhibitions. One, referred to above as associative inhibition, is the fact that if one association has been formed with an idea, another cannot be made with it easily for a little time. It was first demonstrated by learning a series of nonsense series, a–b, c–d, etc., and then attempting to learn the first one of each pair in connection with a second syllable, a with m, c with n, etc. The association that has been formed in the first series will prevent the formation of the second unless a greater number of repetitions are used than was needed for the formation of the first association. The associates seem to interfere and the association first formed blocks the formation of the second. When two possible associates are shown at the same time this inhibition may be present. In the presentation of material each pair of ideas to be associated should be shown alone if the maximum ease of learning is to be attained. It should be said that the inhibition is strongest when the first pair of elements are only partly associated. After the connection has been thoroughly established it happens frequently that it is easier to learn the second in connection with the first.

Avoid Inhibition in Study.—This has one important educational application in the learning of foreign languages. As generally taught, learning a foreign language consists in large part of forming an association between the English word and the equivalent foreign word. It is found to be undesirable to attempt to learn two foreign languages at the same time. The reason is that to learn

the second involves associating a second word with each of the English words before the first association is thoroughly established, and results in confusion. If one is learning French, part of the process is remembering that "house" is *maison*, "cat" is *chat*. If one attempts at the same time to learn German, one must associate *gebaude* with house, *katz* with cat, etc. These two associates interfere when both are in the process of formation. If one postpones learning the second language until the first is well learned, the associations do not inhibit each other. Learning may even be easier.

Reproductive Inhibition.—The converse of associative inhibition is reproductive inhibition. This interferes with recall. If one attempts to repeat either of two associates learned in connection with a single element, each tends to delay the other, and the recall is slow. In many cases the recall will be impossible. As a matter of statistics, there are more times in which one or the other of the two possible associates will present itself than there would be when the first syllable had been associated with one alone. This is because there are two associates possible and while each is less likely to come than it would be had the other not been learned, there is a greater chance that one or the other will be recalled. The inhibition shows itself in the longer time required for the recall of either and the fact that on occasion there will be an obvious blocking in which neither will appear. The best instance of this in everyday life is seen in those cases in which one cannot recall a name or word which is perfectly well known. At such times there is a marked strain and discomfort from the struggle. Later, the idea comes when there is no par-

ticular occasion for it,—when, we may assume, the blocking or inhibiting associate drops out of the way.

Practical Applications in Education.—The avoidance of these inhibitions will do much to make the student's learning easier. He should if possible never be taught anything incorrectly at first and then corrected. What is more difficult to manage, he should not be permitted to learn a wrong thing for himself and then asked to correct it. These confusions are likely to interfere with the recall of the right answer even after he has been thoroughly drilled on it. Even advanced students are confused, if they are given too many opposing theories or statements about any fact or theory. While many of these alternatives must be stated at times if the students are to appreciate the real state of opinion in the science, it is always at the risk of having no one of them recalled, or of having all indefinite.

Limits of Inhibition.—It should be said that when the student is sufficiently familiar with the different alternatives, the attitude of mind, or the task and purpose of the moment, will serve to give the proper associate the right of way and will remove the effect of the inhibition. Were this not the case, the many instances in which it is necessary to remember two things in connection with a single one would all be stumbling-blocks for knowledge. As it is, the inhibitions make trouble only when the two associates are but weakly established, or when the intention of the moment is temporarily in abeyance.

LEARNING OF IDEAS

Learning of Sense Material.—These then are the important practical laws of learning as established by

experiments with meaningless material. In any discussion of meaningful material, of material that deals primarily with ideas, they hold basically, but may need to be modified in degree. Material that has meaning has wider associations with other knowledge, so that the work of learning is partly completed in advance. In all appreciation, even of the most simple experiences, we develop general laws. We tend to remember or recall these general laws rather than the particulars which gave rise to them. A large part, at least, of what we call meaning in our ideas is the reference of the idea as a particular fact to these wider generalizations. These generalizations are not obviously different from the particulars, in fact most of what we call our real things or real bits of knowledge are generalizations of this type. Whenever we see an object we add to it the typical instances or cases which most nearly resemble it, and the thing that we see is in large measure a combination of the particular sensations and the type to which it is referred and which it most nearly resembles. In consequence of this constant use and repetition, the general types are repeated frequently and because of this repetition are remembered where particulars would be forgotten.

Remembering by General Ideas.—It might be said that the type is not in our experience distinguished from the particulars. We think of it, if at all, as a particular that is a standard, or of a particular case in which all of the chance and illusory conditions of perception have been eliminated, and only the true elements retained. Even this we almost always see as the immediate object of perception and are content with that. We neglect the particular elements that depart from it in character.

In the same way, laws and more general principles are formulated and take the place of the particular elements. These, when established either by observation or by acceptance from others confirmed by observation, become similar points of reference for the new material. Our knowledge is nearly all made up of these general principles. The particular fact is a general idea with the additional memory that it was confirmed by this or that experience. The system of general statements and principles constitute the background, the warp of our more particular knowledge. It is constantly being modified as new particulars are added or as new principles come to change or replace the old. It is always the point of reference of our knowledge and constitutes a very large part of it.

The Nature of Meaningful Learning.—Learning of meaningful material is different from the formation of associations in mere rote material, in so far as each idea or fact is connected with and judged by this preformed system. When we read for meaning we unconsciously attach the new statement to an old principle; we see it as a new illustration or exemplification of the old, or we see that the old must be modified in some way to fit it. This fact that appreciation of meaningful material consists in large part of reference to the old and familiar, makes learning very much easier. Why it should be easier to associate an idea with one already itself known, already a part of the great mass of our knowledge, is not very clear from general principles. If we illustrate by it the topic under discussion, there is no general principle established in other connections which would lead us to believe what we are now assert-

ing that it would be easier to form an association between a new and an old than between two new. For that reason it is not clearly understood. Still the fact remains that it is easier. It may possibly be due to the fact that we are certain to recall sooner or later the familiar principle, and that all that is necessary to complete the process is the addition of the new particular.

Sense Material Learned More Easily and Better Retained.—Whatever the explanation, it is a fact that learning of sense material is much easier than learning of nonsense. It has been variously estimated at from ten to thirty times as easy. To put it more definitely one can learn at one repetition from ten to thirty times as many words if they are part of a selection of verse as if they are given without any connection. Similarly, retention is very much more permanent. Ebbinghaus found that he could remember stanzas of Byron's Don Juan that had been learned and forgotten several times, twenty years after the original learning. He could detect the difference between stanzas that had been learned twenty years before and those that had never been learned in the number of repetitions required for relearning. They were about as easy to recall as nonsense syllables learned six months before.

Laws of Rote Learning Hold for Sense Material.—So far as tested all of the laws that have been established for rote learning hold as well for sense. The only difference is in the fewer repetitions required for the learning and the slighter amount of deterioration with the passage of time. On the whole then every advantage rests with the method of learning for meaning. It should be utilized wherever possible. Practically all of the material

of the school curriculum is or becomes meaningful with the course of learning and advancement in the school years. Each new subject may begin as pure rote memory. Much of that, however, can be connected with knowledge acquired in life outside the school, and so be given meaning from the beginning. After any subject has been partly learned, further acquisition can be made to connect with the principles already acquired. The degree to which this can be done is a measure of the teacher's skill and will be a measure of her success, and also will measure the rate of the student's progress.

RECOGNITION

Recognition is Due to Arousal of Old Associates.— One further fact should be mentioned in connection with memory, that is the process by which we assure ourselves, on recall, of the correctness of the suggestions that arise. This we know as the process of recognition. It is the final stage and in many ways the most important of all. When one needs an idea in a given situation, one memory image after another will present itself, but several may come before any is accepted. The accuracy of memory depends very largely upon the degree in which one can distinguish between the true and the false in this recall. Unfortunately the psychologist can give no suggestions to help in the development of this capacity, and can give no rules or few rules of any great importance in the control of its separate applications. Recognition seems in last analysis to be due to the arousal of older associates and general principles in connection with the entering idea or sensation. Part of this is undoubtedly due to the reference to the typical

generalized experiences that we mentioned above as so important for the development of meanings; in part, it is due to the arousal of explicit single ideas or settings. It recalls the other objects with which it was presented before. Usually it is explicitly no more than a general awareness that one suggestion is correct. This state of assurance, we may conjecture, is in turn due to the partly aroused associations, or the partial opening of association paths, on the occasion of the entrance of the new sensation or the return of the old idea.

Recognition the Warrant of Memory.—Whatever may be the process, it is certainly a measure of the accuracy of the memory processes, and is the final arbiter of acceptance or rejection. It seems to be closely connected with the general tonus or state of health of the individual. Janet reports that hysterics and others whose mental life is at a low tension are likely to fail first in recognition. They will in some cases recognize everything, will have the feeling that everything new as well as old has been seen somewhere before. Other individuals will not recognize anything. They will find the most familiar objects altogether strange. Pick found some instances in which gross plagiarism might be explained by this defect of recognition. One may think of it in general as a reaction of the earlier acquired experience, upon the entering experience or recalled idea. These associates give the consciousness of newness or familiarity.

Rules for Recognition.—Of rules of practical import concerning its working we have few. One that has been tested empirically with reference to writing examinations is that in case of doubt it is best to trust to the first rec-

ognition. Study of the changes that had been made in the answers on examination papers of several large classes, showed that in the majority of cases the changes had been made from the correct answer to the wrong one. This is in harmony with adjuration, frequently given, to trust your memory. It is probably wise to accept the first reaction in recognition, unless you can find explicit reason to the contrary. If you can see that the answer first accepted is definitely out of harmony with certainly known general principles reject it. Partly this is due to a natural tendency on the part of a nervous person to wonder whether what has been accepted or read really is right. These doubts are more likely to be wrong than the first reaction. Aside from this, one can do no more than to say that recognition is an immediate response of the individual, dependent upon his previous knowledge, and that it comes correctly according as the individual is or is not capable of accurate memory. It is one of the best measures of the individual as it is of the recall itself.

METHODS OF STUDY

When we turn from the results of the scientific experimental study of memory to practical applications of them to study in the class room, we must be guided largely by the general principles there established. The rules that have been given for studying have not been carefully tested or at least the results of the tests have not been published where they are readily available. We can take some that seem to work in practice and check these and add others on the basis of the general principles we have been developing.

1. **Be Active.**—One of the first from which we may develop specific rules is that a student will learn most and most quickly if he will be as active in his responses towards the material to be acquired as is possible. This activity should be both of attention and of bodily reaction, even if bodily reaction does not accompany attention in every case. Activity of attention can be attained by reading with a particular end in mind. The recently advocated project method, if it be more than a new name for an old method, emphasizes this in so far as it links up as much as possible of the school work with a real end. Reading a book to obtain the answer to a question makes sure that one will obtain the answer, while if we read the book just for the sake of reading it we may get very little. Very likely we shall get nothing on that particular topic. The value of many of the methods such, in particular, as the Montessori, which link the learning with the answering of questions which rise naturally to the child rest upon this principle. What absorbs the attention will be retained while knowledge given when the child is not aware in advance of its importance has much less effect and is much less likely to be remembered. In studying, the student should frame questions in advance of the reading. These keep him alert during the reading and assure more complete attention.

2. **Apply What is Learned.**—Similarly, if a student will put in practice the knowledge obtained, will make an instrument that embodies the principle, will draw the object under discussion, in fact will do almost anything that embodies bodily reaction, the learning is much more assured than it is if there is no reaction, if the individual is passive all of the time. One method that can be used

in almost all material is to require an outline, prepared thoroughly and handed in for inspection and correction. These may become merely routine and perfunctory, but they cannot be prepared without some reaction on the material, and in so far are beneficial.

Our first rules, then, would be to study always with a definite object, with a plan, for the attainment of that plan implies definite attention.

The second is to react if possible to the material that has been acquired. Make an instrument or toy that embodies it if possible. If not, draw it, if the subject of the lesson permits of drawing. If not that, at least outline.

3. Attend Fully.—Any plan that requires vigorous and definite attention favors learning. As much can be learned with a few minutes of fully focused attention as by many repetitions, and much more time given with partial attention.

4. Distribute Repetitions.—Repeat the material to be learned on as many different occasions as possible. Try to study on more than one day and if possible have the recitation on a different day. Divide and conquer.

5. Learn as a Whole.—Always read through whatever is to be learned as a whole, rather than attempt to learn by parts.

6. See Rational Connections Between Parts.—Make sure of the connections between the different lessons. Regard them always as parts of the larger whole and not as units for themselves. This can be done by reviewing in thought the earlier lessons and checking up by review anything of which you are not certain. This at once leads to dividing the repetitions and to uniting the parts of the whole.

7. Intend to Recall.—Read always with the intention of learning. If you catch yourself just reading, remember that you intend to recall.

8. Recite.—Attempt to recite as soon as you can remember any part.

9. Read Rapidly.—Read as rapidly as you can and understand. Read slowly enough at first to be sure that you understand, then more rapidly as the material becomes more familiar.

10. Practice the Rules. Do not Merely Know Them.—It should be the duty of the teacher from the earliest grades onward to see that the student actually practices these rules. To know them, even to approve them, does no good unless the student is made to practice them, until he develops the habit of using them on all occasions. This is much more difficult as well as more important than teaching them.

It will be found that the better students will have developed rules that are adapted to them, and that they will be less aided by using other rules than the poor students. All, however, will profit. Much more attention than has been given heretofore should be given to teaching how to study, from the primary grades to the university. The application of supervised study where thoroughly carried through has been highly beneficial, and will become more effective as we learn by practice more of what the best rules are.

INDIVIDUAL DIFFERENCES IN MEMORY

Memory Types.—Not all individuals can use the same methods of learning any more than they can use the same methods of performing physical exercises.

Many of these are of sufficient importance in details, if not essentials of practice, to deserve consideration. One of the first differences studied experimentally depends upon the differences in what are called memory types. These differences were first indicated in connection with the studies in the deterioration of memories in cases of brain disease, and seem first to have been specifically noted by Charcot. He found that if one man had a lesion in the auditory area of the cortex, he would suffer very much more severe impairment of his memory than would another individual. When he questioned the patients about the way in which they recalled objects, he discovered that the first man trusted largely to the sounds made by the objects or to the sounds of the words that represented them, another depended more upon the visual elements involved in presentation or recall.

This work, which was hardly more than suggestive, was repeated in great detail by Galton. Galton would class all men with reference to the sense that they used most in presenting or representing the events and objects to themselves. The largest class he found to be the visualizers. These used visual processes in recall and in thinking. In fact, his data refer almost entirely to the degree in which visualization is used. Some, he found, would recall objects almost as they were seen with every detail perfect, others would have relatively little imagery, but would supplement their pictures with other sense material. Galton, however, inclined to the view that a man was definitely of one type or another and that men fell into groups. Most of the more recent investigations tend to show that the

differences are not so great or the classes so sharp. Nearly all individuals have more than one form of imagery. In a group of more than a hundred students examined by Professor Griffitts, whose results are not yet published, it was found that all but possibly three had some degree of visual imagery and relied on it almost exclusively in recall.

Forms of Imagery Differ in Degree Rather than in Type.—It is more nearly true to say that there is a difference in degree of dominance in forms of imagery than distinct types. The nearest approach to types found was that between individuals who tend to use concrete images in recall, definitely to reproduce the object as it was originally perceived, and those who tend to translate the experience into words and to remember the words alone. Here again the words may be recalled either as they were seen on the printed page, visual verbal, as they are spoken by the subject, motor verbal, or as they are heard when spoken by some one else or by himself. The first class is relatively small, the second is probably the most important, although many seem to combine the latter two so thoroughly that it is difficult to tell which is which. It should be noticed again that of these main types, two may and usually do exist side by side in the same individual. He will remember certain things in concrete imagery of the actual objects, others he will first translate into words and remember the words that describe them. Only now and again, if at all, do we find individuals who are exclusively of the concrete or of the verbal type. The exclusively verbal seems to be more common than the exclusively concrete.

Change of Type with Age.—There is probably a progressive change with age in the character of the type. Meumann thinks that children tend to be motor or auditory until they approach the school age and then to become more visual. This one would expect to be true only of the verbal, not of the concrete imagery. Until he could read, a child would recall words in the auditory or motor forms. Only when he could read, could he have recall of words in visual terms, and only seldom then does he use the visual imagery for his words. Galton said that there is a gradual loss of visual imagery with age, that many of the older men whom he questioned had relatively little visual imagery while the younger men trusted to it very largely. The older men whom he examined were many of them scientists who made much use of abstractions, and would probably incline to the verbal type.

Dependence of Memory Upon Imagery.—What differences the type of imagery will make in learning depends upon many factors. The differences are largely nullified in practice by the fact that all objects tend to be translated into the type that the subject uses most easily. Show an object to individuals of the verbal type and they will translate the essentials into words at the moment and be able to give as good a description of it as a man of the visual type. This translation, which goes on all of the time, compensates very largely for any differences one might expect to find in the ability to recall, so far as that is related to the mental type. Only in extreme poverty of some one type of imagery is there any noticeable effect upon capacity. Occasionally one finds a student who fails in geometry be-

cause he is incapable of picturing clearly the figures that he is describing. The same capacity is demanded of the morphologist of the artist, and in some degree of the engineer. Even here one would hesitate to advise a student not to enter these professions merely on the basis of an examination of his imagery. If he fails one may find an explanation in the lack of the appropriate imagery. But with our present knowledge, there is so great a chance that a man who seems to lack the appropriate imagery will develop some other way of representing objects which will do just as well, that to bar him from a chosen profession in advance of trial just because of some imagery defect is not warranted.

The effects of types of imagery in practical learning are known, so far as known at all, only from the observations in experiments with nonsense syllables. Here incidental phenomena only appear with reference to the mental types. An individual of a definitely visual type in the ordinary use of the term will be distracted by attempting to repeat the syllables aloud, another of the auditory or motor type will be at a loss to learn unless permitted to speak them aloud. These seem to be the exception rather than the rule.

Binet and Müller found, in actual practice, differences between the abilities of lightning calculators, according as they showed one imagery type or another; an individual of the motor type seemed to be more rapid in simple calculation but more restricted in the problems that he could solve than the two of the visual type whose results have been recorded in the literature. The latter could perform additions of a greater number of columns and could repeat the columns either vertically or hor-

izontally, while the former was restricted to the one order in which they were given.

It is also not safe to draw conclusions *a priori* of the capacities of different types. One would think, for example, that only a distinct visualizer could play chess blindfolded and carry in mind all of the moves of his opponents. As a matter of fact, chess players who have been examined are found to remember in some abstract concepts and to make practically no use of visual processes in recall. While then a teacher may do well to take mental imagery into account when he finds a pupil who fails in some one respect while generally capable, one may on the whole trust to natural compensation of one type by another to correct any one-sidedness of mental endowment. Specific adaptations of the curriculum to meet individual cases are seldom called for. Training of some lacking memory type in an individual who may happen to be hampered by an extreme deficiency may be warranted as an experiment, although we know next to nothing of the limits within which training of this type is possible.

Quick Learners and Slow Learners.—There has been much discussion and considerable experimentation to settle the question as to whether there are distinct differences between individuals with reference to the rate at which they learn and, what is practically more important, whether it is better to belong to the quick or the slow type. Early, the belief was generally held that a law of compensation existed by which the individuals who learn slowly also forgot slowly, so that years later they might be on an equality with or superior to the quick learners. Experimental results as a whole

do not confirm this opinion. On the whole they indicate that an individual who is quick to learn retains better than the slow learner. The first experiments by Müller and Schumann showed that an individual who learned very slowly relearned in a smaller proportion of the number of repetitions required for the first learning than did an individual who learned quickly. This is a doubtful advantage when we note that the quick learner required fewer repetitions to learn and to relearn than the slow learner to learn alone. The later investigations by Miss Norsworthy using a German-English vocabulary and Henderson using sense material both indicate that, on the whole, the individuals who learn quickly retain better what they learn, measured either by the time required for relearning or by the proportion of material that can be given without repetition, than do the slow learners.

The only possibility left that might indicate an advantage for slow learning is in the case of material that offered great difficulty to the understanding in which the reader who learned slowly could spend more time in the interpretation of the ideas as opposed to the mere learning. This case has not been tested, and so speculation on it is not worth considering. Henderson found a small number of exceptions in certain groups of his students, but the exceptions were not numerous enough, or sufficiently consistent as to material used or as to type of student to justify formulating any definite rule that would limit our general one.

Possibly and very probably we could make a distinction with reference to types between individuals who learn most readily by rote and those who tend to learn

by ideas or rationally. This can be seen in the way different students prepare a recitation in geometry, the first of the school subjects which must involve independent thinking or at least the memory of the ideas rather than of the words alone. One group will commit the demonstrations to memory word for word, the other will see how it goes and make sure that he knows the principle, and then trust to his own understanding, his own reconstruction, for the recitation. This difference may be rather more a general type of mind than of learning. It probably also is rather more a habit of study, than a definite deep-seated peculiarity of type. Certainly it can be eliminated by training and by insistence on thinking, although it is not always easy to break it in an individual thoroughly set.

On the whole it seems that the individual differences in memory are not sufficiently great to require any considerable amount of adaptation of methods of teaching to them. Rather it is possible and profitable to the student to overcome the individual idiosyncrasies and to learn to adapt himself to the general methods of the school. Only in the case of unusual departures from the normal, as in memory types, need they be taken into account and then usually to change the type or at least to change the habits so that the individual may profit from the general form of instruction.

QUESTIONS ON CHAPTER IX

1. How is memory related to habit as a nervous process?
2. Where are memories retained?
3. Is there an analogy for memory in the visual after-images?
4. What errors in observation induce errors in the memory of a witness?

5. Give the law for increase in errors with the passage of time.
6. Why are errors more numerous under questioning?
7. Distinguish range from accuracy in the recall of a witness.
8. Is it better to learn all at once or to distribute the repetitions over several days?
9. Give all the reasons for the facts as contained in your answer in 8.
10. Under what circumstances is reading as a whole more effective than learning by parts?
11. Does learning go more quickly with the intention to recall?
12. What is the course of forgetting?
13. A man whose finger has been cut off by a saw asserts that he has not been near the saw. How can you explain the defect of memory?
14. Distinguish associative from reproductive inhibition. How does the difficulty illustrate the facts?
15. How does recall of sense material differ from nonsense?
16. How does memory change with age?
17. What influence has imagery type on memory?
18. How do you recognize a face?
19. Give a series of practical rules for study that may be suggested and enforced in school.

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CHAPTER X

THE LAWS OF PERCEIVING, READING AND TEACHING TO READ

The operation of perceiving is not what we are accustomed to think it, from the naïve point of view. It is really a process of construction in the course of which the sensations received from the sense organs are supplemented by memories to produce the final result. That the sensory impressions are modified is evident from a number of facts both in normal and abnormal perception. 1. We add memories to supply what we do not

FIG. 12 —To show the existence of the blind spot and that it is ordinarily filled up from the surroundings. Close the left eye and look at the cross. Move the book in and out seven inches from the eye and the black circle will vanish.

see. The best instances of this is the filling in of the area that falls upon the blind spot. Where the optic nerve enters the eye there are no sensitive endings, and in consequence the eye is blind at that spot. This can be seen if you will look at the point marked X in the diagram, Fig. 12. If you will adjust it slowly back and forth some seven inches from the eye you will see that the black circle vanishes. This is when the circle falls altogether upon the blind spot. Ordinarily, however, you do not notice the blind spot because you supply from memory or imagination the sensations that ought

to come from it at the suggestion of the parts of the field of vision that surround it. You supply the outlines that are merely hinted at in a Cole Phillips drawing. Also you supply the blocks of letters when the shadows that they would cast are alone indicated. This addition is the most frequent and striking change in perception.

2. Perception Omits Inconsistencies in Sensations.— In the second place, we frequently subtract from the sensations present during a perception some of the elements which we have learned do not belong to the object. Thus, almost all objects seen leave an after-image that lasts for different periods. A red color is followed by green, blue by yellow. They can be easily seen if we look for them, but we do not ordinarily see them, because we know that the surface at which we look is not colored by the after-image and we are interested only in knowing what the real color of the surface is to be. A color will also induce its complement in the surrounding area, a yellow will always be bordered by a blue, a green area by a red. We do not notice these so-called contrast colors, because, from experience, we know that they are not really present. The artist makes us see them by painting his shadows purple. This probably overemphasizes them, because if he painted a gray upon the green background of the lawn we would see that purple to the same degree, that we see it in the ordinary object. Still, his painting makes us see the shadows in the contrast colors that would be actually present in the eye, but which are overlooked in nature because we know that they are not present.

Perhaps a still better instance is that we do not ordi-

narily see the network of blood vessels in the back of the eye which we must look through to see any object. In the front coat of the retina are numerous branches of a blood vessel that enters with the optic nerve and spreads with it over the surface of the retina. These small vessels are between the sensitive part of the retina and the light and consequently cast shadows upon the rods and

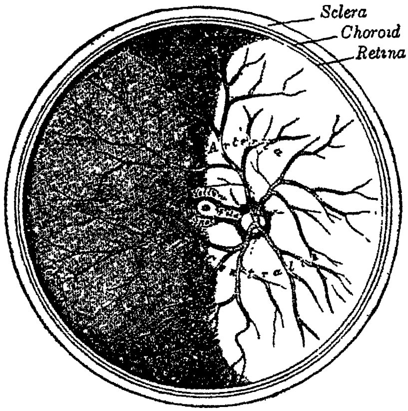

FIG. 13.—Shows the back surface of the retina. The bloodvessels are seen spreading from the blind spot. The position of the fovea is also indicated.

cones which are stimulated by the light rays. These shadows can be seen if one will, in a dark room, bring a candle or an electric lamp a little to one side of the point of clearest vision and move it rapidly in a circle. They stand out as a dark veining upon the surface at which one looks. They are seen under these conditions because they fall upon a new surface and attract attention because they are in motion.

Perception is of the Corrected and Generalized.— In the third place, there may be an almost, if not quite,

complete reconstruction of the object offered to the senses in the light of knowledge derived from past experience. In this case the actual sensations offer no more than a cue for the recall of the object which has been found on test to be the true source of the stimulation. As one explores the cavity in a tooth with the tip of the tongue, one does not notice the separate points, one is aware only of the cavity that they outline, and this usually as a picture rather than as a series of impressions of touch.

Space a Construction.—In the same way, one is not at all aware of the various elementary sensations that are used in the estimation of a distance. One sees the object at a given distance immediately, without knowing how the impression is derived. By a series of objective analyses we know that strain of muscles within the eye, and of the muscles attached to the eyeball that turn the eye, together with double images, furnish the basis for the estimate of distance. But distance is not these sensations. It is, rather, a general idea that may have been developed in one of several and probably in many ways. One needs some way of picturing to one's self the fact that when an object has a certain size or gives a certain degree of strain, one must walk a given distance to reach it. One does not think of the strain in the eyes when one walks that distance nor does one think of the distance that must be walked when one feels the strain. He thinks in both cases of the distance as a definite if somewhat abstract idea. From these and many other experiences the individual has developed a way of representing to himself this distance. We call this way of representing a distance or other abstraction a concept.

Together with other ideas of breadth and position it constitutes our idea or notion of space.

Whenever we have occasion to interpret either strain sensations, or the distance we have walked over, we do it in terms of this concept. The notion has been developed because it was necessary to think of these relations. From that necessity, as a result of trial and error, the individual hit upon the particular idea or form of representing distances. When he found that it would meet his needs of picturing the relations, he adopted it.

The Concept as Representative of a Class.—This process is typical of the development of what we know as concepts in general. By concept, we mean a general idea. A concept is of two kinds. It is first a way of representing several objects at the same time, by means of a single idea or image. In the second place, it is a means of representing general properties which are common to a number of objects or experiences but which are never found alone. The first is seen in the general terms, such as man or dog, which represent all things of the same class. The name of the particular is transferred to indicate all that are similar. In representing the class, the mental content may be an image of a particular, or it may be merely the word that has been attached to all. The value of the word or image is determined by the objects that are suggested by it. If it recalls or tends to recall only one object it is a particular, if it recalls or might recall a number of objects, it is a general idea or concept.

The Concept as an Abstract Quality.—The second type of general idea represents, not a group of particulars, but a quality that is common to a group of particulars.

It is similar to the former type in that the quality that is common may constitute the characteristic that leads the separate objects to be put together in one class. Thus life and motion may be regarded as the qualities that lead man to group animals into that one class. Life and movement are qualities that do not exist alone, but which are prominent in the interpretation of many objects. Life, at least, is difficult, if not impossible, of definition, but is easily and very generally recognized and understood. It is necessary to refer to the quality as characteristic of the class, and so, for convenience, a separate name is given to it. Then the quality, from frequent recognition, comes to be regarded as distinct from the objects or beings in which it is found. Space is a concept of this type.

The Development of Concepts. Noting Similiarities.—In the child the notions develop on the basis of the recognition of similarity. Frequently they are misnamed, or a name is given which is not universally applicable. Even these names give possibility of generalizing and of recognizing similarities. My son at two began to call an automobile a go-go. Soon the wheel came to him to be the prominent phase of the car and go-go was transferred to anything round. The letter *O* was a go-go, also his navel, as was a circle of any type. This was the process of abstracting the quality of roundness. If a conventional name had been attached, it might have stood for the process of abstraction in general.

Development of Concepts by Failing to Note Differences.—It should be said that at an early age, it is possible that a concept is the result of failing to notice differences rather than of picking out the similarities. This

holds rather more of the earlier stages and of the results of inattentive observation than of the higher processes that result in the development of real ideas of a general character. In fishing a trout stream, I have thought I had gone back to the same spot, only to find that I had picked a new place where eddies and pools were similarly arranged. The effect of a mistake of this type might be to take an individual to a place where the fishing was good, although the immediate cause was the failure to note differences rather than abstracting the character that made a particular conformation of water likely to attract the fish.

Overlooking Differences and Noting Similarities.— Both probably combine to transform the separate objects of perception into these generalized concepts or types. In consequence, after the general notion has developed in these ways, whenever one sees an object that belongs to that class, one understands it by referring to the group either by giving it the name of the class or by arousing the general picture that has been evoked through frequent observation of the different similar objects. When referred to the class, it seems to be understood as well as recognized. While we usually speak of this process under the name of cognition or of conceptualization, it really constitutes one of the essential phases of the process of perception.

Formation of Types by Harmonizing Inconsistencies.— In the process of forming the concept or general notion of the group of objects, one not merely abstracts from and forms groups of the various separate objects, but one also transforms the separate objects as perceived singly to constitute a more adequate notion of each as

well as of the group. One never sees the same object under exactly similar conditions. Seen from a different angle it takes on a different shape; seen from different distances it will take different sizes. Part of the process of forming a unitary notion of even the same object seen at different times consists in transforming all of the views into one that shall be standard, that is really correct as a compromise between all of them taken together. A table top is never seen with the corners as right angles, the sides always converge away from the eye. Nevertheless, we always see the table top as square. It is only as the child learns to draw that he becomes aware of the apparent convergence of parallel lines towards the vanishing point.

FIG. 14.—The transformation of right angles in natural objects seen in perspective.

One is not conscious how one developed the correct notion out of all these different images. The development of the correct idea was complete so early that we have forgotten the process, or the memory of the early incorrect perceptions has been crowded out by the later correct ones. Probably it has been a gradual process of trying until we hit upon a figure that shall fulfill the conditions of seeing and also of practical test. When we must make an object that shall look like the rectangle we must make it with right angles. We see that it fits into square corners and all of the practical tests that we can apply are satisfied by the concept of the rectangle. At present, and for as long as we can remember, when a square surface has been presented to us in the horizontal

plane it has been translated into a surface as it would be seen in the vertical plane opposite the eye. All of the characters that depend upon perspective have been eliminated and we see it as square.

The Concept in Perception.—The concept contributes to the development of the percept in two distinct ways. 1. We tend always to see each particular as representative of a class. 2. We see the object replaced by a corrected standard object. The first influence of the concept is partly a process of understanding that extends beyond the object itself. Whenever an object presents itself to consciousness, part of the perceiving process consists in referring it beyond itself to related experiences and general notions. The mere naming consists in part of a reference of this kind. It recognizes the particular as belonging to the general class. Even when there is no naming, there is still a recognition of the class of objects to which the particular belongs. This reference to a class is not merely an addition of something else to the object or a mere external grouping with other things; it also tends to modify the object itself. Perception may consist in nothing else than in accepting the fact that this is another elm. If one is searching for a nut tree in the fall that is all that one cares to know. The perception is little more than an identification. In that case, the identification closes the perception process and so has a negative influence. The individual is content with that, and may receive nothing more from the experience.

Concept May Replace Percept.—In the second case, the actual content of the percept is markedly modified by the reference to the standard or concept. One does

not merely refer the new to the old, one also transforms the new in the light of the old, without even appreciating that the new is changed. All that one is aware of is of the object as changed, and the change consists in little other than the substitution of the corrected object for the raw data. The corrected standard object has been built up as a result of a large number of experiences and is of a character to harmonize all of the experiences with or of the object. Sometimes, as in the general notions of space or time, the elementary experiences are not to be detected in the general notion which is used to interpret them. One has an actual experience that one designates distance, in addition to the name or the general awareness that an object is remote, but it is not possible to analyze it into any more elementary sensations. We may assume that the idea of distance has been developed through experience, by uniting and correcting numerous particular experiences of reaching, of walking to an object, and associating these with the strain and other elements of vision which present themselves in connection with the movements. The final form that the experience or percept of distance assumes is of a visual quality. There is no detectible element of strain or of movement, but it must have been developed through these by a process of cut and try until the notion or way of presenting the experience that we call distance was hit upon. Now that experience comes each time one looks with no indication that it is not itself the result of a single experience.

Classes of Concepts in Perception.—Ultimate and unanalyzable experiences of this type are time, motion as a visual experience, rhythm, and probably many other

fundamentals, such as force. Although force is possibly less definitely a concrete percept and more a general category of our first class, each of these comes into perception when certain definite conditions are met. When it comes it has an immediate acceptance. It is more general than a thing, but quite as concrete in immediate experience. One perceives space or time just as definitely as one perceives the sun, or a tree. The same series of experiences have made possible the development of both kinds of notions, and the same laws of association serve to suggest them at the appropriate moment.

Reading a Typical Perceiving.—We shall not in this discussion go into the detailed description of the way these more abstract perception processes develop. A treatment of them may be found in any text on psychology. Instead we illustrate the general laws of perception by an outline of the way we read, for reading is perhaps the most important perception process in education and involves all of the general principles of perception. Essentially, reading is a supplementation of certain visual signs, first by words as they are spoken and then by the ideas or images that they are intended to convey.

Reading as Supplementation.—In the process of supplementation, each of the principles that we have indicated to be present in perception in general can be shown to be involved in reading. In the first place, reading is a process of supplementing a few lines or letters clearly seen by others which are supplied by association only. The mechanics of reading show that this must be the case. Modern experimentation has shown that reading is a process of taking brief snap shots at a line of print

and then reconstructing the words actually present from these relatively imperfect partial views. Photographs of a beam of light reflected from the cornea of the eye show that the eye makes a series of pauses here and there in the line, and sees nothing between these pauses.

Reading Pauses and Reconstruction of Words.—The pauses last for approximately one-fifth of a second and, during the pause, the eye is directed upon points variously scattered over the line. Between the pauses the eye is in such rapid motion that nothing could be seen but a blur of after images. It is an illustration of our second law of perception that nothing is noted that does not have definite meaning, that nothing is seen during this period of motion. The individual learns in infancy that nothing can be seen to advantage while the eye is moving and forms the habit of paying no attention. He is not even aware of the blur of objects that must be stimulating the retina at that time. It has been said with picturesque force that the individual is cortically blind during this movement. In consequence there is no observation of the movements themselves and until experiments were made it was generally assumed that the eye moved continuously along the line seeing one word after another.

Number of Pauses Decreases with Familiarity.—The number of pauses made in a line varies greatly with the length of line, the familiarity of the material and its difficulty, and with the skill of the reader. At a minimum there will be from four to six for easy material as in newspaper or novel, with much greater numbers for scientific or philosophical matter. Gray found on the average ten pauses per line for third-grade pupils and seven for

the college student. In proofreading the eyes also pause often, an unconscious result of the desire to see each letter. These pauses are distributed fairly regularly

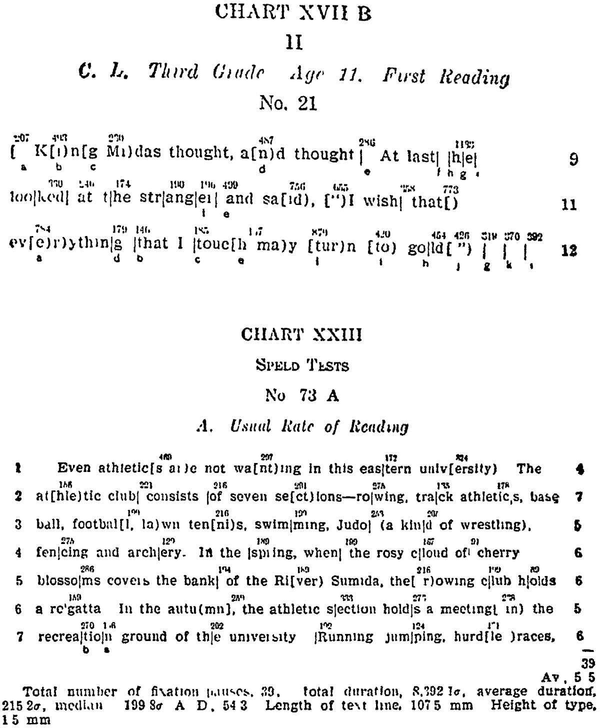

FIG. 15.—Shows the distribution of eye stops in reading. The numbers above each line indicate the duration of each pause in thousandths of a second. The upper selection was obtained from a child in the third grade. The lower shows the stops of an average adult.

within the line. The first is near the beginning, with younger children usually on the first letter. The last is usually a considerable distance from the end. Obviously it is necessary to see the first words more clearly, since

once they are seen the others may be to a large extent supplied from context. A comparison of the distribution of reading pauses for a child in the third grade and for an adult at the usual rate of reading is shown in figure 15.

Reading as Supplementation by Associates.—The pauses are near enough together to permit all letters to fall upon a part of the retina where they may be distinguished, but probably the material taken in at each glance is greater than the single span of attention. Certainly it is greater than the span for isolated letters. This, it will be remembered, was at the maximum five. A short line in a book will have forty to fifty letters which would give about ten to the reading pause or about twice the normal span of practiced attention. This would mean that not all of the letters would be clearly seen during the pause. We have direct evidence that reading is not merely receiving the external impressions into mind, but an active process of supplementation. The best indication is offered by the proofreader's illusion, the tendency to overlook mistakes in words. No matter how carefully the untrained reader looks he will not notice all of the mistakes in words. Even the trained men are subject to the illusion at times as is shown by the fact that very few books appear that do not contain a few errors of this type.

Interpretation Dependent on Context.—Study of the character of the mistakes and of the conditions under which they occur indicates that in all reading one sees only a part and supplies the rest. Difference of opinion has developed as to what is the exact part seen. I long ago pointed out that one was guided both by the general outline of the word as a whole without reference to the

letters and by the prominent letters, usually the first letters of the word. More recently workers have divided into two camps: one holds that it is the general outline of the word, the other that it is the first letters of the words, or the first and last. The latest work indicates that either method may be used, and that which predominates depends upon the reader and the degree of familiarity with the material.

The process of reading would be, first, to observe the general form of the word as determined by the length and the arrangement of high and low letters. In addition the first few letters and one here and there through the mass will be noticed. These two elements together serve to suggest a word or group of words. If letters are changed throughout the word, particularly near the middle, the change will not be noticed. In rapid reading, a word that has the same general shape and length as another may be substituted for it and the substitution will not be detected. Thus "thee" might replace "thus" and if the context demanded "thus" it would be read in spite of the lack of the "us."

The laws that we follow in the interpretation of the words seen have been studied by exposing words with different types of mutilation for an interval of less than a fifth of a second, the period which the eye pauses in its normal reading, and determining the frequency of the mistakes and the character of misreadings that are made. The interpretation follows the laws of association. Between letters, a letter that has frequently been seen next to one that is exposed will be supplied without knowing that it is supplied rather than really seen. Thus any letter after "l" at the end of a word is likely to be re-

placed by a "y" because of the frequency of the adverbial ending. There is also an immediate association between the form of the word as a whole and a word, as indicated in the substitution of "thus" for the "thee" in the instance mentioned above.

Association in Perception Guided by Setting or Context.—It is a general rule in association that not merely the closeness of connection between the elements determines what shall follow a given experience, but also that the wider conditions of consciousness, the purpose of the individual or the attitude into which he is thrown by the experiences that have gone before serve to select the possible associates. This holds of perception as well as of recall. I experimented upon this with isolated words, by showing a word after first calling a word that would have some association with the word that I desired the individual to see. Under these conditions the errors or misprints were very much more likely to be overlooked, than they were when no indication was given as to what the word was likely to be. Unconscious attitudes were also prominent in determining the character of the associations that were effective. A student coming from a French class would see combinations frequent in French, although the words shown were all English, and a man who stopped reading a German book to begin the experiments saw German groupings that were not in the letters shown.

In reading under natural conditions of connected material, the control is determined both by the general thought and by the words which have immediately preceded. Thus if an intransitive verb has preceded we may expect an adverbial form with its "ly" ending, and a

word will be supplied with that ending if its general form will permit. Each beginning of a sentence will similarly limit the associates that may be possible in that context. The words and general forms of words must suggest only those associates that harmonize with that context. Only words or letters will be suggested that have been associated with the forms actually seen; but of the ideas associated, only those will be permitted to come to full consciousness that harmonize with the context. Thus the reading process as a form of perception is initiated by the few letters and word forms that are clearly seen, these are supplemented by other letters or complete words that have been associated with them. It should be added that the reader never distinguishes between the letters that are actually seen and those which are supplied mentally through association.

Reading Aloud and Silent Reading.—We must distinguish between reading aloud and silent reading, as the associates are different, the purpose is different, and even the eye-movements are different in the two cases. In reading aloud, the end is primarily associating a sound with the word seen. To this end, the word must be seen and understood, but there is probably, in most cases, a definite arousal of the kinæsthetic or the auditory memory of the word, which immediately precedes the movements of pronunciation. In addition there must be a wider understanding as there is in silent reading. If this were lacking, the reading would have no proper feeling or intonation. It becomes, when the individual is practiced, an almost automatic process in which the movements are evoked at once by the sight of the words. The eye-movements are also distinct in that the eye pauses

on each word, usually near its beginning. The word is more definitely the element in reading aloud. In silent reading the phrase is the unit, and the eye largely disregards the division into words.

Supplementing in Silent Reading.—In silent reading, the supplements are primarily ideas. One translates from the words seen directly or indirectly to pictures and more general ideas of what is in the mind of the writer at the time he wrote. This supplementation may come after the motor or acoustic representation of the words, or it may be direct. In the less practiced, it is usually after the word has appeared in one of the more familiar forms. In the more practiced readers, at least with easy material of a descriptive character, it may consist in a translation of the image of the words into pictorial ideas. The laws of association act as before, but the material associated is the picture that the word represents, rather than, or in addition to, the sounds or the movements that would follow hearing the words spoken. In this translation, the unit with which the idea is associated is not the word but the phrase.

It is hard to say how the translation goes, because the reader is not aware of the words seen first and then of the ideas that interpret or supplement them, but of the ideas and images alone. The scene that is described comes into his consciousness in a series of continuous images, with only occasional awareness of the words that convey the ideas. When there is some difficulty in interpretation or the language is not quite clear, the words are noticed. At other times the material depicted occupies consciousness to the exclusion of all else. Probably the associations are partly with the phrases seen and partly

with the ideas aroused by earlier parts of the matter read. These mutually interact to give the reconstruction of the thought of the writer. Always the words must check the flow of other associations, to insure that the interpretation agrees with what is said in the matter read. It is a process of rethinking the train of imagery of the writer, not merely of seeing each word and associating with it a single idea.

Reading and Inner Speech.—The fact that we are first familiar with words in spoken language and that early reading is nearly always reading aloud for a considerable period leaves in many individuals, sometimes even in the adult, the tendency to have the words repeated in inner speech, before the ideas arise from them. On the whole, this is a disadvantage, particularly for rapid reading. One can think the ideas or pictures to one's self much more quickly than one can reproduce the words. Study of the rate of reading of both children and adults has shown that the individuals who read through the intermediary of inner speech, think each word as they would pronounce it themselves, read more slowly than those who pass at once to the ideas. On the whole, it should be the aim of teachers to break this habit as early as possible just as it is desirable to break the habit of reading half aloud. In fact this use of inner speech is left over from reading aloud or moving the lips in silent reading. Instead of pronouncing each word, the image of the movements that would be made is evoked, or the muscles are partly contracted, and this takes as much time as reading aloud.

Inner Speech Eliminated by Rapid Reading.—Breaking the habit can best be accomplished by insisting

upon as rapid reading as is possible as soon as silent reading is well established as a routine. If the pupil is constantly pushed by the length of lesson, or by the amount he is expected to report upon after a given period of study, a little beyond what he can accomplish easily, he will be obliged to make use of short cuts. One of the first of these will be to drop inner speech as an intermediary between the word seen and the idea. This indirect method is much more effective than calling attention to inner speech with the warning that it is to be avoided. This is likely to break up the natural routine, and by keeping attention fixed upon pronouncing the words to himself to increase the evil. One university senior, an honor student, was told that it was a very slow method to read by thinking the words to himself. He took the matter very seriously, watched himself constantly while studying, and while he could not conquer the habit, lost most of a semester's work through the distraction it introduced. While so serious an effect is probably an indication of an unstable nervous condition, still the emotional and distracting effect of trying to avoid a habit fully established is at least temporarily injurious. Insistence upon speed will accomplish the same result more quickly, certainly, and with less inconvenience and emotion.

The Lag of Perception Behind the Eye.—Experiments show that one reads a considerable distance behind the eye both in silent reading and in reading aloud. This was shown by shutting off the material to be read at a given point and noticing the number of words that could be read after the page disappeared. It was possible also when photographing the eye during the reading to know

at what point in the line the eye rested when the shutter closed. In silent reading the same method was applied except that the subject must be relied upon to say how many words came into perception after the material from the page was shut off. In each case it was found that reading was a considerable distance behind the eye. The more adequate the reading, the greater the lag of the voice or of comprehension behind the eye. On the average the lag was about three words in third-grade readers, and about four and a half in high school and college students. With individuals of the same age or attainment, it is also found that with the better readers the voice or understanding keeps farther behind the eye than with the poorer.

The explanation is that the words seen after the words that are pronounced also influence the interpretation. In reading aloud this makes possible better modulation and in silent reading one understands the group of words as a whole. The completion of the understanding requires the words that come after the last word ideated, if one reads in silent speech, and the understanding lags behind the word on which the eye is momentarily fixed.

Translation into Ideas.—One other interesting phenomenon completes the reading operation. This is the translation into ideas. One not merely reads words as one reads silently, but also reads images and ideas. In reading aloud, the reader and his hearer also receive ideas as the final aim of reading. When the material is easy description, the adult reader little notices the words themselves. He has the view that the author describes floating through his mind. The print suggests immediately the pictures or ideas, the words do not come to

consciousness. In more abstract material, the words may persist or may be about all that strikes consciousness, but they are important always for their meaning, not for the words themselves. In certain abstract ideas, the meanings are more closely connected with words than with pictures or other imagery. In that case, the understanding stops with the words, or is evoked immediately by the words.

Perception of Objects.—Perception of any object follows approximately the same course as reading. A few sensations are given directly. These are supplemented by the addition of recalled experiences to fill in any gaps that may be left, and correct any inconsistencies. This supplementation is through the ordinary laws of association, controlled by the mental setting, derived from what has been seen just before, and by the other objects in the environment. In the interpretation, the entering experience is frequently referred to the general class to which it belongs. It always is understood by being assigned a general class.

Perception and Illusion.—Sometimes when the wrong associations are strong, something will be added that has been associated frequently with the sensations that enter, although they are not appropriate to the situation at the moment. This is one way in which an illusion is produced. Again when the individual is in an attitude of expectancy for one class of objects, the associates will be directed to give an object of that type, although neither the natural association nor the strong association favors it. An illusion of the first type can be seen in the case of the filling of the blind-spot mentioned above. An illusion of the second type when one sees a

lighted tombstone as a ghost when one is walking through a graveyard at night, especially after reading a ghost story. Figure 16 shows how additions may change an object.

In short, perception is a process of mental reconstruction, in which sensations initiate the process and ideas are evoked to supplement them. When the reconstruction gives a result that proves on test to harmonize with the facts, it is known as perception; when it proves false, we have an illusion. The laws are approximately the same in both cases, truth or falsity depends upon whether the result is confirmed by the later tests or not.

FIG. 16.—Ink-blot.

QUESTIONS ON CHAPTER X

1. Look fixedly at a small point and have a helper move a moderately large object out towards the temple. Indicate when you no longer see it. Mark the spot on the wall. Now look at the field of vision. Does the spot mark the limit of vision or do you seem to see something beyond?
2. How is a group of sensations changed in perception?
3. Give instances of the participation of the concept in seeing.
4. Distinguish between concept and sensation.
5. How do concepts arise?
6. Give an instance of the way space perceptions are standardized and corrected.
7. How does the eye move in reading?
8. What relation between the reading pauses and the character of the material read?
9. How much is seen and how much supplied in a line of reading?
10. What is supplemented in different type of reading?
11. Give the advantages and disadvantages of associating sounds of words with the words seen.

12. Outline the process of understanding ten words read in a foreign language.

13. How is an illusion different from an ordinary perception?

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CHAPTER XI

REASONING AND TEACHING TO THINK

We are constantly told in connection with education that one of the chief functions of a school is to teach the individual to think, not merely to fill him with facts that he can only repeat parrotwise. All would agree that this is a highly desirable end, provided it could be attained. One may well ask what are the probable limits of training and how it may best be established. For this we may best begin by a definition and an analysis into its elements of the reasoning process. For if we are to know how the function may be trained we need to know as completely as possible the processes of which it is made up.

The Phases of Reasoning.—The modern attitude towards reasoning makes it not an entirely peculiar function but a new combination of relatively simple part processes. Two different operations are ordinarily called reasoning. The one is the actual physical manipulation of objects, movements which accomplish what cannot be accomplished by habit and instinct alone. The other is attaining by thinking alone ends that could be reached only by long trials through actual movements. What amounts almost to a third type is the reasoning of the scientists which consists essentially of understanding experiences, reducing the world as a whole to a form that admits of being given a simple plan. We find common elements in all forms of reasoning. All may be reduced

to the same general plan and be divided into the same part processes.

Reasoning Always Problem Solving.—Reasoning is of all degrees of complexity from certain of the more complicated activities of the higher animals to the solution of the most involved problems by the mathematician. Still in essence the more complex can be traced from the simpler. Analysis of the simplest offers an advantage to us, since it is easiest to understand and upon it we can build the new complexities contained in the more developed forms. All forms are alike in that they occur only when the thinker is thwarted in his activity, when some problem is presented which earlier experience and instinct have not prepared him to solve directly. The ape that is given a loop of rope and a banana placed within reach of the rope but beyond reach of his paw must do something analogous to reasoning to solve his problem. He has the desire but no known means of satisfying it. What he does is to make a series of movements with the loop, throwing it out towards the banana, until after many trials he succeeds in getting the banana in the loop and drawing it in.

The Stage of Reasoning.—If we analyze this or any similar act of a higher animal that is not due to instinct or to habits, we see that it involves three steps. There must always be a more or less vague awareness that something is to be accomplished, that the present situation may be changed in a way to give greater pleasure or satisfaction. The ape, *e. g.*, must know that the banana is there and must be sufficiently hungry to make it appeal. In the second place he must have at his disposal a number of movements, one of which will

ultimately bring him the banana, and in the third place he must know when he has attained the end,—to be efficient he must know when he has attained each particular stage in the accomplishment.

In the animal no one of these processes need be more than vaguely conscious. Sight of the banana calls out the series of responses, with probably little definite idea of what is to follow, and without necessarily having an idea of the movements in advance of making them. The movements themselves are probably in most cases old habits which are transferred from connections in which they have been formed to the situation in question. The ape must have had some experience in poking for objects beyond his reach with sticks, and may have had experience with other loops. The more similar the movements to those needed in the situation, the quicker will be the attainment of the end. If the ape appreciates the partial successes or early stages in the attainment of the end, the final success will come much more quickly. If for example he sees that the loop is encircling the banana after a throw and appreciates that that is the time to pull in, he will secure the banana much more quickly than he will if he again pulls back for another throw. Even in the lowest form there will be appreciation of the final success when the banana is within grasp, even if that consists in nothing more than in evoking the instinctive reaction of picking up and eating.

Human Thinking Like Animal.—Human thought takes approximately the same form but is ordinarily conscious at several places where the animal thinking cannot be known to be aided by consciousness. The occasion for all human thinking is the same as for the complex animal

action. Thinking always arises from the need of attaining something which is seen to be needed, and which instinct and earlier acquired habits or knowledge do not suffice to attain for the individual. Man, too, thinks only when he must.

Analysis of the Problem.—Given the problem in the appreciation that something is wrong or that something can be improved and the next step with man is one that the animal probably does not go through, this is the analysis of the given into its elements to determine exactly where the difficulty is and the point that should be attacked to remove it or to improve the situation. If it is an automobile that has stalled the driver must look to one after another of the points that have failed him at some time before, until he finds what is wrong. If the scientist discovers a new fact that is not in harmony with an accepted theory, he must see first exactly where the deviation from the theory lies. When the schoolboy is solving a problem in geometry, he must first discover what the essential factors in the problem are and where one must begin to make constructions to bring this particular problem under the class of some known solution.

Judgment.—This process of analysis we know as judgment. It consists in essence of referring the new situation to an old or to a general class that has been developed by consideration of a number of older experiences. It is reference to a general notion of this type that constitutes the process of understanding. One must understand before one can act. The more completely one understands, the more adequate is the action. In this the man is probably very different from the animal. The animal merely notices that something is wrong and makes

more or less chance movements until the difficulty is righted. The man may do the same under certain circumstances: In seeking to untangle a bit of cord, he is quite likely to pull at any loop that presents itself until he finds one that comes through easily to give a single end. Even here, unless the tangle is too complex he might do better to study first the adjustment of loops until he sees one that constitutes the key to the structure or one that will at once give a free end. The reference of the tangle as a whole to these simple easily movable parts is judgment. In this case the idea to which it is referred is a particular, although the notion that it is a loop which will pull free is a general notion or approaches a general.

In solving the problem in geometry, the thing that prepares for the success is seeing the new or given as related to some old figure. One is prepared to deal with the proof that derives the number of right angles contained in the angles of a polygon, when one sees that a polygon may always be divided into triangles, and that the number of triangles that may be drawn always bears a definite relation to the number of sides. That possibility of analysis is the step that prepares for the solution. It constitutes what we call the judgment. In this case the analysis is to a more general notion. The triangle would ordinarily be called a concept.

Inference.—The second active step in the reasoning process is finding the solution. In this man acts very much as the animal does. If it be a problem to be solved by movement, as in untangling the mass of cord, the solution may consist in nothing more than the series of movements that takes so many different directions that

they may be regarded as chance. On the other hand, it may be purely in idea. The man who is solving the problem may merely sit and wait for the association processes to provide an idea that shall supply the needed solution. Or of course it may be both. Very frequently one thinks out a solution of a given problem and then must build a machine or a piece of apparatus that shall embody the solution. Even when the idea seems to be satisfactory in thought, it not infrequently happens that the working model does not work, and it is necessary to modify it in some ways during the building or after it is completed. Thus the solution of a problem may be either in movement alone or in idea and in movement.

Movement and Idea Follow Approximately the Same Laws.—In general the two processes follow much the same course. There is usually little foresight as to the movement that is to be successful and none as to the way in which ideas are to follow each other. Both are trial and error processes. The movement of untangling the cord if one does not analyze is exactly like that of the ape. If one does analyze, one sees in the tangle certain elements which may be easily attacked, loops which may be easily drawn, but the way in which they shall be drawn may still be a matter of chance. The interplay of chance factors in the solution after analysis is more obvious where the problem to be solved is more complicated. In the invention of the cotton gin, analysis showed that it was necessary to find some mechanism that would catch the seeds, but it required many suggestions and considerable time before the means could be found to carry out the suggestion that was made in general as a result of the analysis of the problem. Similarly

after the polygon has been seen to be composed of triangles, it may take some time and many attempts before the lines are drawn to make the triangles mutually exclusive, and at the same time include the entire polygon.

In both the movements and the ideas, the separate attempts come by chance or by virtue of neurological laws that are not fully known. The individual cannot control them. He knows the end that he desires to attain; he cannot, however, make the exact movement required to attain the end, or evoke the idea exactly appropriate to the situation. He can only keep trying and hold himself ready to utilize the suitable idea when his nervous system presents it to him. Both idea and movement come as a process of trial and error in which all that the thinker or actor can do is to wait, with mind intent upon the end, and keenly alive to appreciate each advance in that direction. Some men have minds in which new ideas spring easily, or new combinations and suggestions come frequently; others do not. Sometimes similarities with old situations may provide either an old habitual movement or an old idea that shall be satisfactory in the new situation. In so far earlier experience may be helpful.

Immediate Appreciation of Success.—One factor in the reasoning process that is so universal that it is likely to be taken for granted is the awareness that the end has really been attained. In the animal, instinctive reaction takes the place of appreciation in many cases, although in animal experiments cases have been recorded in which the individual solves the problem and does not recognize it. Watson had a white rat that opened a door but did not enter because it did not notice that it was open.

The child may similarly solve a problem of a mechanical sort by a series of trials and not know that it has been solved. In the solution of a mental problem there may be failure to accept the right idea when it comes, or still more frequently, the wrong suggestion is mistaken for a correct solution. The ability to distinguish the right from the wrong suggestion grows with experience and is applied immediately. It is closely related to recognition. In the expert in a given field acceptance or rejection of a suggestion is certain and quick, in the man who knows less there is much hesitation and there are also frequent mistakes. As for recognition no rules can be given, except that one should know all that one can of the subject in which the decisions are made.

Proof.—After the thinker has accepted the solution as adequate, it is frequently necessary to convince some one else of its correctness. It is also not infrequently desired to justify more specifically the immediate assurance of appropriateness that leads to tentative acceptance. This process of proof is the part of reasoning that has been studied by the logician. Briefly, one proves that a statement or a suggestion is true by relating it to earlier experiences. These earlier experiences may be formulated in general principles, which have already been accepted, or they may be more particular experiences. If one seeks to justify the use of helium as a substitute for hydrogen in a dirigible, one could do it either by saying that it is not inflammable and is nearly as light as hydrogen or one could refer to actual experiments in which bags or balloons had been made to rise with helium. If the justification is by reference to older organized experiences, the process is called deduc-

tion. If one proves by reference to particular experiences or by trying a crucial case, the proof is said to be inductive.

Deduction and Induction.—Both induction and deduction have the same fundamental explanation. Both are dependent upon experience. The only difference is that in induction the separate instances are kept distinct either as single cases, as averages of definite experimental series, or are stated statistically as in our proof for the inheritance of mental capacities formulated in coefficients of correlation. In deduction, on the contrary, proof is given by reference to general principles which have been developed from experience, undoubtedly, but which have been accepted so generally that nobody thinks of asking what the particular instances are that led to their development. Probably the immediate acceptance of the suggestion that the man gives who has these experiences is due to their action. When the suggestion harmonizes with the experience of the individual he believes it at once and is ready either to act upon it or to accept it provisionally for more definite proof. Proof consists very largely in making explicit the knowledge that induced the original acceptance.

The Concept.—Both the judgment and the process of proof rest upon the presence in the individual of earlier knowledge that has been given this general form. The concept can be given the same general explanation as the meanings that were mentioned in connection with memory. Familiar words have the function of representing objects or ideas with which they have been connected in the past. When the word comes it is used as if it were the object or group of objects with which it

had been connected. It represents them in consciousness. When we think the word we know that what we say of it will hold of the objects it represents as well. Without entering into the more detailed discussion we may say that there is probably a partial excitation of the older association paths that have been aroused in connection with the objects. These act for thought very much as if the older experiences were really in consciousness. We are prevented from asserting anything of the word that we could not with truth assert of the objects. The concepts, and the word is one form of the concept, makes it possible for us to think of the many in a single thought.

Once the concept has been developed, it is used in place of the particulars. We refer the situation we are analyzing in preparation for its solution not to each of the similar situations experienced in the past but to the concept that represents them all and has developed because it unifies and represents the essentials of each. In the same way our proof is a reference to the generalized experiences expressed in terms of a general law or axiom, that has arisen as an expression of a large number of particular experiences. We know when we state the law that we might test it by recalling each of the particulars that is included under it and the statement would hold accurately for each. This representative function of the concept is one of the most important in all thinking. It makes it possible for a single mental act to take the place of many, without the loss of accuracy that comes from including the many.

Reasoning.—We can see from this brief sketch that while reasoning is the most important in many ways of

the mental operations, it still develops from the same general principles as the simpler. Reasoning always starts because the progress of the moment is thwarted by some obstacle to thought or to physical progress. This is usually first analyzed into its elements, that we may proceed as quickly as possible. Then familiar movements are applied in new connections, or old associations present themselves in a new setting to supply the solution. Usually there are a number of attempts before a suggestion appears that is accepted as satisfactory. The several attempts are rejected until the fortunate suggestion arises. Acceptance is first immediate because the idea harmonizes with the earlier experience, then the suggestion may be proved to the satisfaction of another or of one's self, by making explicit reference to generally accepted principles or to concrete facts.

Training to Reason.—Obviously training to think is only possible through the development of habits in connection with the separate phases of the reasoning operation as outlined. First, one should learn to distinguish between the situations in which one can to advantage proceed by pure chance movements and those in which one must analyze the situation and select the point of application of the trials. In most human situations, analysis will to advantage precede action. To keep cool, and examine the situation to discover the most likely point of attack, usually saves time over trying blindly the series of movements that may lead to success. If no point of attack can be discovered, and the problem is a physical one, then one can to advantage proceed by a series of trials until success comes. If the

problem is a mental one there is not much hope of solution unless one finds a means of reducing it to its simplest terms. In that case one should continue to seek one after another means of reducing it to known elements. Sooner or later more or less definite reference to something else will present itself and there will be a chance to begin the attempt to discover the solution.

Training in Inference.—The best advice for accomplishing the second partial operation in the reasoning process, finding the solution, is again to keep thinking of the problem as analyzed from as many points of view as possible until a suitable suggestion appears. The right attitude will do much, confidence that a solution will be thought of may be even more effective. Thinking systematically of all similar situations that one has met, may give a suggestion. Reading of similar problems and their solution will often give a cue even when the bearing is not direct. The student can develop the habit of believing that he can solve the problem, and of waiting and thinking until a suggestion comes. In solving geometrical problems one can by encouragement change an individual who believes that he cannot work original demonstrations, or one who believes that they cannot be solved, into a fairly competent student. This may be accomplished by suitable encouragement and by practice with relatively simple cases, until the student acquires confidence and the habit of trying patiently until he thinks of the right solution. That there are differences between individuals in the ease with which suggestions will present themselves, cannot be denied. Reasoning is probably the mental factor most closely related to intelligence. Still, the competent are some-

times prevented from realizing their capacities by the presence of bad habits and by lack of confidence. These may be remedied within wide limits.

Training to Prove.—Probably the most important phase of reasoning is the selection of the correct suggestion when it comes. This depends very largely upon the experience of the individual in the particular field. If a man knows a subject his acceptance or rejection of a suggestion will be valid, or at least worthy of respect. If he knows less of it, we can assign little importance to his belief. This knowledge can only be acquired in advance and so all that can be said in that connection is a reinforcement of the general adjuration to acquire knowledge. Over and above the possession of knowledge there are differences in attitude towards the product of one's thinking that can be made the end of habit formation. The child may be taught to pass upon any suggestion of his own or of another independently of all authority. This means that he should ask whether in the light of knowledge of other related things the statement that is made to him or the idea that presents itself is probably valid. Some are inclined to accept everything. A few of these can be led to develop the habit of relating to the general knowledge and obtaining a basis for acceptance as approximately correct or as widely erroneous.

The same habit may be applied with advantage to the results of memory. One may be trying to recall a definite sum that has been mentioned as paid for a house, or as the amount of a national debt. It is always possible to check the recall by reason. If the sum that comes first to mind is somewhat vaguely recognized, it is well to

make a farther test by considering how the figure stands in comparison with the sum paid for other houses in the same neighborhood, or with the debts of other countries. While this test may be fallacious in times of changing prices and of rapidly increasing debts, it is nevertheless sufficient in many cases to cause one to seek to confirm the memory, when it departs much from the general average. The habit of questioning each suggestion of one's own or another and of checking up on memories in the light of agreement with what has been learned before is essential to the individual who would think for himself and not merely accept the results of others. The assurance that follows may be carried too far, but it is to be preferred to the mere parrotlike repetition or complete dependence on others.

Training in Demonstration.—This last phase of demonstration is the real subject-matter of logic. We need go no farther than to say that the student may be taught to apply the more important rules of logic so far as it is deductive by actual practice in the demonstrations of geometry. The habit of making sure that each general principle that is used in proving a given conclusion has itself already been established, may be developed and when developed may in some degree transfer to other situations. If it does, one step is taken in the improvement of the capacity for reasoning. Of course it is true that one may make rigid demonstrations in geometry and not extend the habit to matters of everyday life. This may be aided by pointing out in other subjects how the same rules may be applied. Each time this is done there will be a double gain, a confirmation of the habit and a realization that it can be extended. To know the

rule and to form the habit of applying it is the only training in deductive proof that is of value.

Argument from Analogy and its Limits.—The student should also be taught in practice the limitations of argument by analogy. This is the form of proof most used. It stands halfway between deduction and induction. It consists in referring the assertion to be proved to a single instance which is not necessarily identical with the one to be proved, but which is taken as like it. If the likeness is in essentials, the proof may have real value; if, however, as happens very frequently, it is in non-essentials, the proof may be entirely misleading. To recognize the limitations of analogy, both in arguments by one's self and in accepting the arguments of others, is one of the most important bits of training in proof. Again it can be taught only by pointing out the weaknesses of analogical reasoning in the cases in which it is applied and by forming the habit of rigid analysis.

Science and Statistics Give Training in Inductive Reasoning.—Training in inductive reasoning should be obtained in the different experimental sciences. To know the value that may be put upon separate instances in the different fields and under the different conditions in which observations may be made should develop naturally as a result of the thinking required in the different sciences. To know that relatively few observations in a physical science under definite conditions and with material that is subject to little variation may give valid conclusions, while many may be necessary in a study of such a complex phenomenon as heredity, is of untold value in the thinking of everyday life. Again

the habit may not transfer, but repetition and constant emphasis upon the differences and the fields in which each type of proof may be applied should in time work an improvement even in the thinking outside of all school or even bookish thinking.

As has been shown, reasoning is little more than an application of the same simpler mental operations that we have been finding in each of the concrete processes treated heretofore. The one new process is the use of generalization and the reference of the new to the co-ordinated earlier experiences. Even this is not altogether new as we found learning aided by the references to the old and the general. Training here as elsewhere consists largely in forming habits of executing the various operations under the most favorable conditions, in learning to trust one's self and to think of each operation as one that must be viewed in the light of knowledge as a whole, that must first be looked at broadly and then treated in detail later on. There is no royal road. Reasoning cannot be correct without broad knowledge of the matter in connection with which one reasons. Given knowledge it is also essential to form the habits of correct thinking: habits of analysis, habits of questioning and of reducing each element in a proof to its lowest terms. These may all be acquired in the subjects of the curriculum, but they must also be transferred to the work of daily life, before they are fully effective. The most that can be said is that constant training with admission of no exceptions in any subject is bound to work improvement in the long run.

QUESTIONS ON CHAPTER XI

1. What is characteristic of reasoning? How different from recall?
2. Outline the stages of reasoning.
3. At what points do the abstract or general terms enter in aiding the reasoning process?
4. Outline the differences between the abstract in perception and in understanding a problem. What types of judgment can you enumerate?
5. Can you teach a child to make adequate judgments? How would you proceed?
6. What is the difference between belief and judgment?
7. Assuming that belief is a reflex indication of the amount of knowledge, would belief or skepticism increase with knowledge?
8. Give any rule you can that will make it easier for a child to reach the solution of a problem.
9. Does the syllogism aid in reaching the conclusion? or in proving it?
10. Why does the formulation of a syllogism make the conclusion seem true?
11. How does argument from analogy lead to conviction?
12. How do statistics increase the probability of an assertion?
13. How is induction related to deduction?
14. What habits may be developed that will affect the adequacy of a student's reasoning?

REFERENCES FOR CHAPTER XI

DEWEY: *How We Think.*
PILLSBURY: *Psychology of Reasoning.*
RIGNANO: *Psychology of Reasoning.*
MILLER: *Psychology of Thinking.*
WOODWORTH: *Psychology.* Chapter XVIII.

CHAPTER XII

FEELING AND EMOTION IN EDUCATION

The driving force in most mental and physical operations is found in the affective life. We act and even think largely to avoid pain and to secure pleasure. So far as there is an ultimate "why" that can be asked and answered in connection with human action and mental life, the answer is to be found in terms of the pleasure that results. The formation of habits we have seen to depend upon the pleasure that results from the first actions. A pleasant act is repeated while an unpleasant one is inhibited or made but once. A movement will not even be completed if pain is caused at its beginning. The pleasure aroused by memories incites to many of the acts that are already acquired, and whose consequences are known. Even where the consequences have never been experienced directly, descriptions of others and imaginings based on instincts will impel to the acts.

Feeling and Emotion.—In theory we are accustomed to distinguish between feeling and emotion. Feeling is the mild component of pleasantness or unpleasantness, taken together with the sensory processes involved; emotion a more vigorous type of response, with numerous bodily accompaniments. Emotions also are either pleasant or unpleasant, but the physical stimuli or the pleasantness or unpleasantness is more intense. What is most characteristic is that the bodily responses are more pronounced. It is altogether a more violent state

or process. At the same time, there are slight bodily responses which accompany feeling, although it is difficult to find any that are altogether confined to either pleasantness or unpleasantness.

We may for convenience discuss feelings apart from emotion with the understanding that they are closely related processes and that what we say of one may be said in some degree of the other also. The qualities of feeling are but two, one accompanying movements of approach and heightened efficiency, the other going with the movements of withdrawal and lowered efficiency. The one we call pleasure or pleasantness and the other unpleasantness. These qualities are probably not directly connected with any sense organs, although from time to time attempts have been made to identify unpleasantness with the pain which comes from a specific sense organ in the skin or muscle and even to connect pleasure with sensations of tickling which are sometimes assigned to a definite sense end-organ. It is more usual to assume that they are in some way connected with the character of the general functioning of the nervous system, or given no specific organic basis.

The Bodily Signs of Feeling.—Feelings are accompanied by changes in the bodily reactions. For a time it was asserted that characteristically different responses could be assigned to the opposed qualities of pleasant and unpleasant. Some still remain, but on the whole the same type of change comes with both qualities. There is only a difference of degree. The one that still seems to offer opposed forms with opposed feelings is bodily movement. There is a tendency to crouch and draw together with pain or unpleasantness and to relax

or expand with pleasure. Similarly, the mouth is dry in unpleasantness, while pleasure gives increased secretion of saliva.

On the other hand, the eye is bright with pleasure, because there is a slight secretion of tears; while unpleasantness in the extreme induces weeping. The blood vessels ordinarily are constricted in both pleasantness and unpleasantness, although at times we may see the glow of pleasure in the flushed cheek, that is only a slighter degree of the flush of embarrassment. Quickened pulse and breathing usually accompany both pleasantness and unpleasantness. On the whole, then, we can assert only that there are bodily changes accompanying feeling, but that few show a difference between the effects of pleasantness and unpleasantness.

Theories of Feeling.—Attempts to explain why pleasure and its opposite should arise, and why they arise when they do, have varied greatly. They may be divided into three groups. The first and most general would make it the accompaniment of an instinctive response. In the large, pleasure is thought of as an instinctive indication of benefit, a go-ahead signal to the organism or the individual, while unpleasantness is a warning of danger. This assumes that on the whole the pleasant is the beneficial, and the unpleasant, the harmful. The statement has a few exceptions. These we may explain if we assume that instincts cannot be absolutely specific, but can only indicate the most general lines of conduct and will suffice to keep the individual alive until he learns. The exceptions are cases that do not occur often. To choose the pleasant, for the vast majority, offers the most probable course of safety.

The Association Theory.—The second theory supplements the first. It makes feeling depend upon the past experiences of the individual. Objects, originally indifferent, which have at any time in the past been the occasion of benefit and so of pleasure will become pleasant. Similiarly, an unpleasantness which has been experienced in connection even with a beneficial stimulus will induce a transfer of that feeling which will finally make the beneficial unpleasant. Pawlow by ringing a bell at the same time that he showed meat made a dog's mouth water at the sound of the bell and if we humanize the experiment, the dog would be said to feel pleasure afterwards at the sound of the bell. A child who finds a bit of shell attached to an oyster as he bites it may acquire a life-long dislike for oysters. This theory assumes an original connection between benefit and pleasure. Granted that, it serves to explain many of the transfers of feeling that all observe in the life of the individual.

The Physiological Theory.—Attempts have been made to relate the different types of feeling to bodily changes. The quality of feeling is made to depend upon general responses of the nervous system. It has been asserted that response of a well-nourished nervous system is pleasant, of an enfeebled nervous system, unpleasant. Marshall has modified this slightly to run that any change towards equilibrium is pleasant, while departure from equilibrium is unpleasant. Thus, if the system is well nourished, action within limits is pleasant, and further rest or recuperation is unpleasant, while for a system below par, rest and all that favors recuperation is pleasant. Many theorists, ancient and modern, have held that action, bodily or mental, against opposition

is unpleasant, while action in harmony with the general tendency is pleasant. Recently Freud and his school have advanced a theory that pleasure is connected with stimulation of the sex instincts or sex organs, the libido theory. Each of these theories harmonizes with certain facts, but can hardly be verified at present.

All of these theories may be combined in considerable degree. Feelings are instinctive guides to conduct in advance of experience. With experience they are subject to modifications that make them more accurate controlling agencies. It is probable, too, that the mental state is connected with a more or less definite bodily state that furnishes the final explanation of the conscious process. This is as yet so little known that we must trust to discussion of the sign or accompaniment rather than to the underlying bodily mechanism.

EMOTION

Emotion as Bodily Response.—As has been said emotion is a more obvious and probably more intense mental and bodily state than feeling, although closely related to it. The modern tendency has been to relate emotion definitely to movement. Evidence that emotional states are connected with specific bodily reactions goes back to the Greeks. Descartes, and more recently James and Lange, revived it and made it more specific. Stated baldly, this theory asserts that one feels an emotion only when certain stimuli arouse some deep-seated muscular or glandular response. The conscious phase is excited only by the bodily responses. Emotion is the awareness of responses of the inner bodily organs, occasioned by some stimulus, in an appropriate mental attitude.

Instinct and Emotion.—Obviously, emotion is closely related to instinct since the movements that result upon the stimuli are due to innate connections in the nervous system. They result without thought, just as do instincts. Two distinctions have been drawn between instinct and emotion. Watson asserts that instinct should be applied only to acts that involve the voluntary or striped muscles and are evoked by the central nervous system, while emotion is the term to designate a response of an involuntary or unstriped muscle which is called out by the nerves of the autonomic system. When startled, the jump would be instinct, while the changes in circulation, the contractions of the walls of the stomach and intestine, that give rise to the feeling of cold, and the mass of sensations from chest and abdomen constitute the emotion. This usage is for the sake of finding a logical division in the interests of a particular theory and does not correspond exactly to the ordinary usage, although there are not very many points where daily usage and the classification do not agree in part.

Emotion the Conscious Phase of Instinct.—McDougall has defined emotion as the conscious side of instinct. The responses due to inherited connections that can be demonstrated objectively, he would call instinct, while our awareness of the responses would constitute the emotions. There are certain instinctive responses such as eating and the simpler locomotor responses that would not have any emotional accompaniments or concomitants. In general, we must agree with Watson that it is internal movements, the sensations from the deeper lying organs that constitute the emotional response. Occasionally a sudden contraction of a voluntary muscle,

as of the facial muscles, or a general bodily start as in fear, will add its quota, but this constitutes the exception rather than the rule. With McDougall, however, we may emphasize the conscious rather than the motor side of the process in our definition. What is important in the emotion is what we feel rather than what we do. The motor processes are largely lost motion. They accomplish little directly.

Our picture of emotion on either theory is that it is a consciousness of the involuntary response of the body to certain stimuli. The stimulus causes a series of responses in the muscles, mainly those controlled by the autonomic system. The sensory ends in these muscles send back impulses to the cortex and we become aware of the response and of the stimulus at the same moment. The total experience is the emotion.

The Utility of the Bodily Response.—The explanation of why these deeper lying bodily muscles should contract as they do is not altogether clear. In general we may regard them as responses made at one time because they were useful but which may or may not be useful to the organism at the present. We can trace the more obvious responses in fear with reference to their use or its lack. The first response may be to run. Under favorable conditions this is the most useful response. How far these movements would constitute part of the emotion of fear might be questioned. If the running were successful it is likely that what seems the characteristic fear emotion will dissolve as the object is put farther and farther behind or even at the moment that all of the muscles are involved in running. Before that, when the fear is most in evidence, there will be a com-

plex of sensations from internal organs that everyone would accept as part of the fear consciousness or complex. These may include a general feeling of weakness, a curious cold sensation up and down the spine, a general trembling, a sinking feeling in the chest, and various other components from numerous internal organs.

A second component that comes in more intense fear

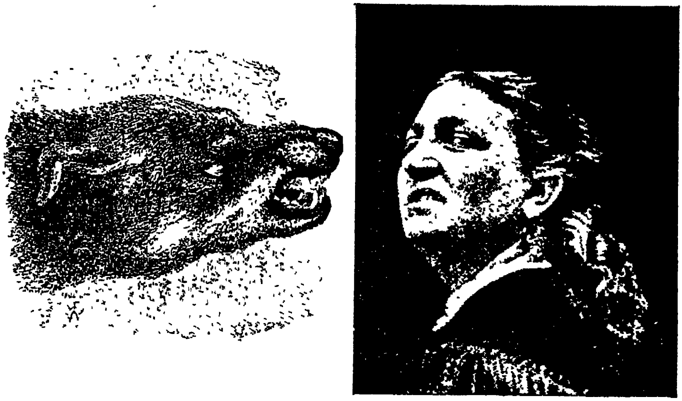

FIG. 17.—Shows the essential similarity between the snarl in the dog and the sneer in man. Compare the position of the lips. (From Darwin's "Expression of Emotions in Animal and Man.")

is a general quiescence or paralysis. Rivers argues from his study of the effects of fear in shell-shocked soldiers that this is a survival from the death-feigning instinct of animals. If a feeble animal remains absolutely quiet, it may escape dangers that otherwise would destroy it. A beast of prey in that case will not observe it. This death feigning is a forced reaction over which the animal or the man has no control. It is probably foreshadowed in the weakness that produces trembling in the ordinary fear. Finally there is a complete collapse,

again according to Rivers, that passes into complete unconsciousness. The last stages probably have very slight utility in man, if one can ascribe any value to them at all. They are of value in the animals.

Transfers of Emotional Expression.—Reactions in

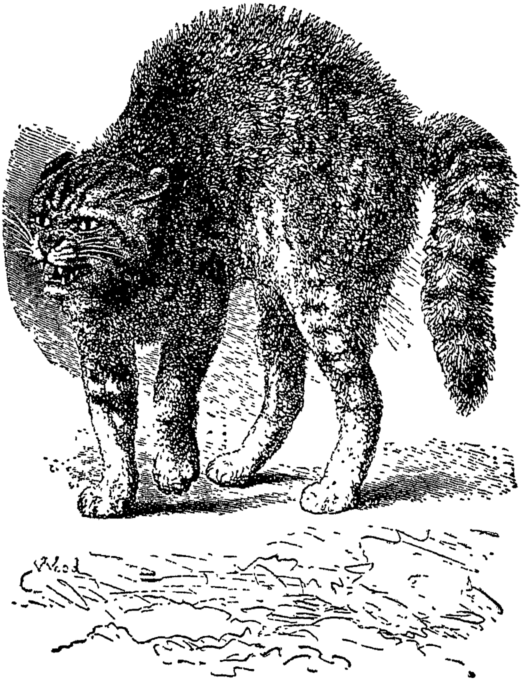

FIG. 18.—Fear in cat attacked by dog. The arched back and enlarged tail give the effect of size and may induce fear in dog. (From Darwin's "Expressions of Emotions in Animals and Man", after Wood).

emotions that have no direct value are thus usually survivals of those that had value. These reactions may be transferred from a response in which they originally appeared to another in some way like it, in much the

same way that metaphor is used in language. In animals, Darwin suggested that there was also an association by contrast in emotion, that a situation opposed in its character to one that evoked a given response, would give rise to the opposed response, whether that response were or were not of value in that situation. He explains the sneer of the man with its drawing back of the lips to expose the teeth as a remnant of the preparation of the wolf to imbed its teeth in the body of the antagonist. The nodding of the head in affirmation is a remnant of the movement the child makes in taking food. He nods to signify taking anything as well as food. They have utility now only as a means of conveying an appreciation of the mood of the individual, but they are derived from the movements that were useful to an earlier form of animal.

The Secretions in Emotions.—The more internal contractions and secretions do not have such an obvious utility. Recently, careful and ingenious investigation has shown that all emotions have an effect in evoking secretions of the glands. The salivary glands and the secretions of the digestive fluids in the stomach have long been known to be influenced by emotion. A pleasant emotion tends to increase the flow of both, while anger or fear or even too great pleasureable excitement inhibit the secretion. The only utility that could be ascribed to the negative response in this case is that the blood ordinarily used in digestion may, in an emergency, be drawn away to the periphery, where it would be used directly in muscular action.

The Endocrine Secretions in Emotion.—More directly useful are the results of the secretions of the so-

called ductless glands, that have been recently assigned so important a place in the bodily economy. Two of these, the adrenal and thyroid, are undoubtedly active in emotion. The adrenal glands are small bodies near the kidneys. Cannon and others have shown by careful experimentation that both in fear and in the excitement of the chase these adrenal glands discharge a substance into the blood that profoundly modifies various bodily processes. It causes a releasing of the glycogen that is stored in the liver and this is then carried through the blood to the tissues for which it provides a readily assimilable food. It also causes an increased heart rate. This, with the increased glycogen in the blood, serves to supply the tissues of a fighting or running animal with more nourishment to replace the loss through the increased work. Adrenalin, the substance that is secreted, also causes a constriction in the small blood vessels and makes the blood coagulate more quickly. These effects together stop the bleeding from superficial injuries. This effect is well known from the use of adrenalin in minor surgery to control hemorrhage.

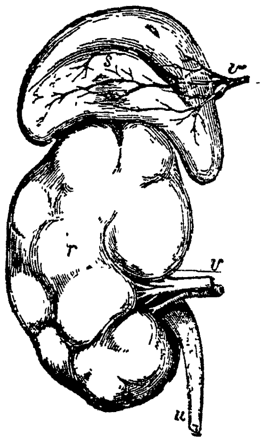

FIG. 19.—The adrenal or suprarenal gland or capsule. *r*, kidney; *s*, adrenal gland.

Emotions and the Thyroid Glands.—The thyroid glands lie in the neck on either side of the trachea below the larynx level and above the clavicle. They have been known for a long time to influence nervous and so

mental action. When they fail to develop properly, as in the cretin, the individual is of very low intelligence and stunted in bodily growth. The condition is known as cretinism. If taken in childhood the patient may be made to develop normally by feeding it the thyroid extract from an animal during the entire period of development.

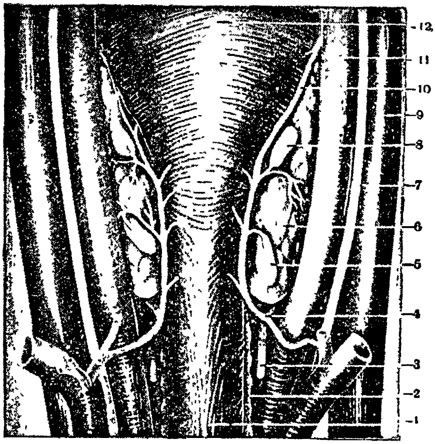

FIG. 20.—Shows the position of the thyroids. 1, Oesophagus; 2, trachea; 5, inferior parathyroid; 6, thyroid, lateral lobe; 8, superior parathyroid; 12, pharynx.

When there is too great a secretion as in Graves' disease, there may be over-development of the general emotional life.

Less specific experimental evidence has been obtained of the action of the thyroid gland in emotion, but clinical evidence indicates that there is a mutual relation between the presence of emotion and secretions of the gland. At periods when there is for any reason an increased secretion of the thyroid there is an increased

susceptibility to emotion. The individual is irritable and all unpleasant stimuli have a much more marked effect than at other times. On the other hand, emotion, particularly long continued emotion, results in a marked increase in thyroid secretion. In diseased conditions it is a vicious circle, in which increased secretion of the thyroid produces increased emotion and that in turn increases the amount of thyroid secretion.

Utility of Secretions in Emotions.—Both adrenalin and thyroxin serve to increase the strength of reaction of the organism and so increase its efficiency. The adrenal secretion is induced very quickly and its effects last for minutes or hours at the most. The thyroid apparently responds more slowly and its effects last for a longer period, for hours and days rather than for minutes and hours. Both affect consciousness only indirectly. Adrenalin may be responsible for the feeling of excitement in emotion. Even this is probably aroused only indirectly through the tenseness of muscles all over the body, which may be due to the stimuli that excite the flow of adrenalin, or indirectly to the fact that adrenalin makes the muscle more ready to respond. The thyroid reveals itself only in the irritability which may be the indirect effect of the thyroid secretion upon the central nervous system.

The Control of Emotion.—While emotion is in general a consciousness of the immediate reaction of certain groups of muscles and glands to a stimulus, there is a possibility of control, within limits. If one is warned that a stimulus is to appear, one may prepare for it by classifying and interpreting it. The natural reaction of most men towards a snake, even a harmless snake, is to

draw back or to start. If one knows that a snake is in a certain place and looks at it with the desire to discover how it can move forward by merely squirming, he will lose his fear in curiosity. One can prepare in various ways to give it a classification that will make it an object of interest, rather than a source of fear. Within limits any object can be changed from the source of a pleasant to the source of an unpleasant emotion, or *vice versa.* This is done by changing the class within which it shall fall. The reaction, then, is the reaction to the class to which the object is assigned.

The Suppression of Emotions.—Much has been made in recent psychological, or more truly, psychiatrical, theory of the bad effects of repressing emotion. It is possible to check the expression of an emotion, or at least the outward expression. Many emotions, particularly those connected with sex, have been placed under the social taboo of civilization. These the individual will not permit to come to expression and will not even admit to himself that he experiences. According to Freud an emotion persistently suppressed in this way still continues to affect the individual, and if long repressed may become responsible for various forms of mental and nervous disease. Freud's general formula is that the child develops the sex instincts and emotions at a very early age and that the systematic training in checking and repressing these responses may be injurious to health. A part of this repression is seen in the refusal to tell the child the truth about sex matters, and even to lie to him in the attempt at keeping him ignorant, an attempt that is usually frustrated by his talks with other children. This general emotional repression fur-

nishes the basis upon which later emotional accidents, usually again those which relate to the sex life, may develop definite nervous and mental diseases.

The Relation of Emotion to Mental Disease.—While it is generally assumed and on good evidence, that there is a causal relation between repressed and conflicting emotion and mental disease, the definite mechanism of the interaction is not made at all clear. Freud's picture is based on an animism, that furnishes at best a very loose analogy. The emotion is repressed, the unconscious, which for Freud is another thinking self, develops habits of defense against the disadvantages that might result from permitting the experience that causes the emotion to become conscious. Some of these defenses involve the production of physical defects such as paralyses, fear of writing or blindness. The effect seems to be altogether too great for the cause. More definitely adequate to the effect is the assumption that the long continued slight emotion causes a marked increase in the secretions of certain of the endocrine glands, and that these secretions in turn produce pathological changes in some of the organs, ultimately, mostly in the tissues of the nervous system.

Mental Hygiene of the Emotions.—Based on these observations, a tendency has developed to recommend that there should be as little inhibition of emotions as possible. This has even been taken to mean, that a child should be freed from all discipline since discipline means inhibition, and is likely to suppress emotions as well as complete freedom of action in all respects. Such an interpretation would of course have many disadvantages. The forces that lead to suppression are the social

forces that impress the ideals of the community which are called upon even in the mildest forms of discipline. Were all suppression of this type to be removed it would result in complete license to the individual. This would be inconsistent with life in the community. If there were but one child to be dealt with at a time, it would be possible. With many, the desires of the children would conflict; some must be suppressed. Strict compliance with the rule would lead at once to chaos, unless one could develop some new compromise that would imply new discipline and new repression.

Discipline Demands Suppression.—Looked at more generally any of the conflicts of life may have a deleterious effect upon the mental health of the individual. Much of the insanity that developed among the men who stayed at home, during the war was traced to the conflict between the duty of fighting and of caring for members of the family at home. These conflicts, however, have the other side of developing the character of the individual. A conflict met and suitably resolved, prepares for dealing with new situations. Without conflict it is hard to conceive of growth.

In considering both the problem of suppression of emotion and avoidance of conflict, we must face two sides of the problem. On the one hand in certain individuals there is danger that to check instinctive tendencies may produce a mental or nervous disease. On the other hand, if children are to learn to live in society, certain of their instinctive reactions must be checked for the sake of other individuals. It is a balance of evils. It is better that two children in a thousand should become mentally disturbed than that all should revert to

savagery. It is better even that an occasional child should develop the seeds of insanity than that all should be permitted to escape the decisions and resulting conflicts that are to develop strong characters.

Sublimation May Replace Suppression.—Fortunately, it is not necessary to choose between the extremes. The teacher can at least avoid all unnecessary conflicts and irritations for the child. He need not constantly be subjected to the disturbing "don't" of a nagging teacher or parent and may yet have his antisocial responses checked and gradually transformed into those of a social character. This can be done in part by the process that the Freudians call sublimation, *i. e.*, by changing the end of the instinct to one that is like the original, but of a character that is permitted or encouraged by society. In part, it may be made the rule not to interfere with any activity that is not definitely injurious either immediately or in its later applications. This applies to the normal child.

The Peculiar Child.—The teacher should be on the lookout for the child who is unusually susceptible to repression, the peculiar child. He may well be given special treatment by being spared many of the inhibitions that are applied to the ordinary child. So far as possible, his emotional life should be kept on an even tenor. Stimuli that cause too violent reactions should be avoided. The child should be given as free a range of expression as is consistent with the minimum of essential discipline. The training must be carried on in cooperation with the parents if they can be made to understand. The problem is frequently complicated by the fact that the condition is hereditary and the parents

themselves are peculiar, are emotionally unbalanced. Aside from freeing the child from undue occasions for emotional expression and also from undue repression, he may be developed through giving him an understanding of social and other relations. This will tend to self-control. Something may also be done by habit formation. This will consist largely in habits of classification of the situations that shall put most in a group that evokes slight reaction, at the same time that it leaves no feeling that the emotional expression itself is improper. Treatment is largely a matter of tact, but recognition of the fact that orderly development of the emotional life is important to the mental health of the child must constitute the guiding principle in the treatment.

If the teacher is to obtain the maximum effect with her charges, she must consider not merely the intellectual but the feeling aspects of their experience. Appeals to effort must ordinarily be to the emotional features. They must, at least, be such as will touch the fundamental instincts and particularly the social instincts. The instinct of rivalry and social approval are the strongest and usually most effective. As in the control of action they should always be used in the positive form of stimulus to endeavor. To use them to check action or to arouse shame over a fault is less beneficial and may develop the repressions that, in the aggravated form, may produce a mental abnormality. The ability to arouse the suitable emotions is a matter of tact,—that is, it is a capacity that is learned by the skillful teacher in the course of experience. Only these most general rules may be mentioned as an indication of what to avoid and of where to attack the problems.

QUESTIONS ON CHAPTER XII

1. What are the incentives to work exerted in the ordinary schoolroom?
2. Are the pleasures the result of work or work the result of pleasure?
3. How are you aware of your feeling? How can you tell if another is pleased?
4. Are signs of pleasure or unpleasantness more or less apparent in the child?
5. Are the bodily accompaniments of pleasantness and unpleasantness different?
6. List the apparent exceptions to the identity of pleasure and benefit. On what theory can you explain them?
7. Why are you pleased by a pretty face? by ice cream? by a compliment? Why are you displeased by a reproof? by a dash of cold water?
8. How can you distinguish feeling from emotion?
9. Emotion from instinct?
10. List the bodily reactions as you look over a high cliff.
11. Compare Watson's with MacDougall's distinction of emotion from instinct. Which covers the greater number of cases?
12. Give three ways in which the bodily responses have utility.
13. How could they have originated?
14. Within what limits may an expression change from one emotion to a similar one in which it is not useful?
15. How do the secretions of the alimentary canal change in anger? in love?
16. List the effects of the adrenal secretions.
17. Of what value are these effects in situations that arouse emotions?
18. How can one control the emotions? Should one aim at direct control of bodily responses or at changing the attitude towards the situation?
19. Outline Freud's theory as to the way repressed emotion may cause mental disease.
20. What general rules are given for mental hygiene based on these rules? To what degree would they hold irrespective of the validity of Freud's general theory?
21. Can conflict be avoided altogether? Would it be desirable if possible?
22. What does Freud mean by sublimation?

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CHAPTER XIII

ACTION OR WILL

The problem of action or of will raises at least three different but related problems. The first is the question of the way movements may be aroused; the second how they are learned so that they appear in a given connection, and finally how they may be chosen one from another, or how an undesirable movement may be checked or prevented from appearing.

The Initiation of Reflex Movement.—It is a general principle which guides all modern physiology and psychology that each idea tends to pass over into action. In the simplest form, the reflex, the movement comes at once when a sense organ is stimulated. Each sense organ has an immediate connection with certain motor neurones and, through those, with muscles that induces a response of some type whenever the sense organ is strongly stimulated. This is true when there is no consciousness. In the frog, for example, when the spinal cord has been cut at the neck so that connection is broken between the body and the brain, stimuli applied to the skin will at once arouse movements of the legs. A leg is at once brought to the point stimulated. Only the excitation of the sense organ in the skin and the passage of the nervous impulse across synapses to the motor neurones that are connected with the muscle is necessary to evoke the movement.

Impulses and Voluntary Movement.—The same general principle holds also for the more complicated movements and those which involve consciousness. Again the sensation or the idea initiates the movement. Nervously, the sensory impulse passes through intermediate nerve structures until it reaches a motor region and then starts the muscular response. The idea may or may not accompany even these more complicated movements. When it does accompany them, the efficient causation is of the same type as when it does not, so far as we know and so far as our present theories are concerned. The real energy that sets off the action of the neural paths and finally starts the contraction of the muscles is from the sensory nerve impulse in either case. We may believe that the idea is important in giving knowledge in advance of what is done, but it is hard to see that it modifies our idea of the mechanical processes involved.

Voluntary Movements.—Voluntary movements are different from reflexes only in that the path of the nerve impulse passes through the cortex rather than through the cord or brain stem alone. Here again every phase of the movement is dependent upon some sensory impression. Sometimes it starts in sensation as when one copies a lecture or a passage from a book. Sometimes it is initiated by a memory or idea as when one speaks on one's own initiative. In either case the real incentive to movement is the excitation of a sensory area. In most cases the movement depends upon both sensation and idea. Usually the idea is suggested by a sensation. The sight of a man suggests the remark that you have thought of making to him. On the other hand, you begin to write notes on the lecture because you remember that

you came for that purpose. It is very seldom that either memory alone or sensation alone is responsible for a voluntary act. It must be laid down as a general rule that all movement starts in a sensory area, and that to understand the movement we must know the idea that precedes it, or the sensory impulse that evokes it, even if the sensory impulse be unconscious.

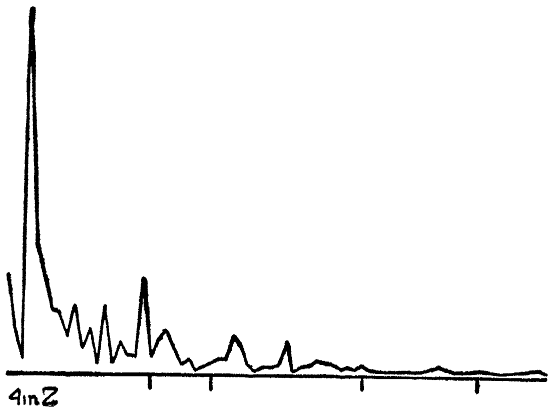

FIG. 21.—Curve of learning in dogs. Height shows time required for hitting upon each correct response. (From Thorndike.)

Learning is by Trial and Error.—The second problem in connection with action is to understand how a specific motion comes to be connected with a given idea or sensory stimulation. The general principle that was first observed in the animals, but which has been proven for man as well, is that the individual learns by chance. One cannot by taking thought unite an act with a sensation. All that can be done is to keep trying the movements that one knows and wait until the chance connections in the nervous system lead a sensory impulse over into a motor pathway. After that movement has been made

once, there will be a tendency to repeat it if the effects are agreeable, and when it has been repeated sufficiently often the habit of making that act when that stimulus is presented will become firmly established.

Learning to Move the Ears.—In an experiment to determine the method of learning, Bair asked individuals to try to move an ear and attached an apparatus to the

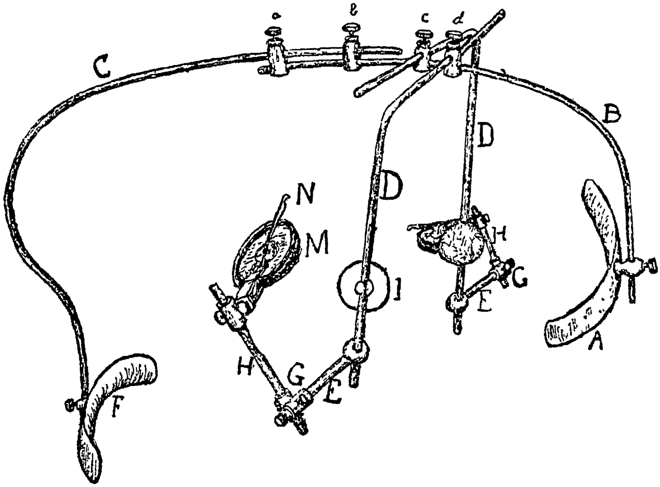

FIG. 22.—Apparatus for recording the movement of the ears. Fastened to the head by *A* and *F*. *M*, a tambour or rubber capsule filled with air. *N*, a lever that fits over the edge of the ear. A tube leads from the tambour to a similar one that records the movements on a revolving drum.

head that should record accurately the various attempts. It was found that the first trials resulted in no movement of the ear itself, but only of muscles of the jaw and scalp that were near the ear. After a number of efforts extending over several days, a slight movement would be noticed. When the subject noticed this by the sensations that came in from the muscle or skin, he could repeat

the movement when he thought of making it. No amount of effort, and no setting of ideas or methods would enable him to hasten its appearance, and he could not say what particular adjustment led to the first movement. He could only struggle and wait until a certain amount of excess discharge found a path from the muscles under control to the muscle of the ear.

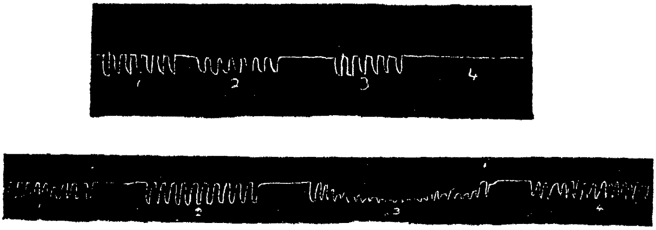

FIG. 23.—Shows progress in learning to control the movements of the ear. In both curves *1* shows the movements due to application of the current alone; *2* shows effect of volunatry effort plus current; *3*, an attempt to inhibit the contraction by the current; *4* is the effect of the voluntary effort alone. The curve above shows the first attempt where the electric current alone has any effect. The lower curve shows the maximum effect of voluntary control. It will be noted that in 3 where the attempt was made to inhibit, the ear was held contracted during the entire period instead of being held relaxed as the subject intended.

New Movements from Excess Discharge.—Even moving the ear for the individual by stimulating it electrically did not teach him to move it. With one group of workers stimulations of that type were repeated many times without the least effect upon the learning. The movement must start with voluntary effort and move from within out, if any learning is to result. This law is of universal application. All learning depends upon the direct effort of the individual who is to learn. You cannot teach a movement by putting the member to be moved through it. You can only stimulate the individual

to try, and tell him when he is wrong. Rules are of no value save as a guide as to where to try and as to what movements should be rejected.

Acquisition of Skill.—After a large number of move-

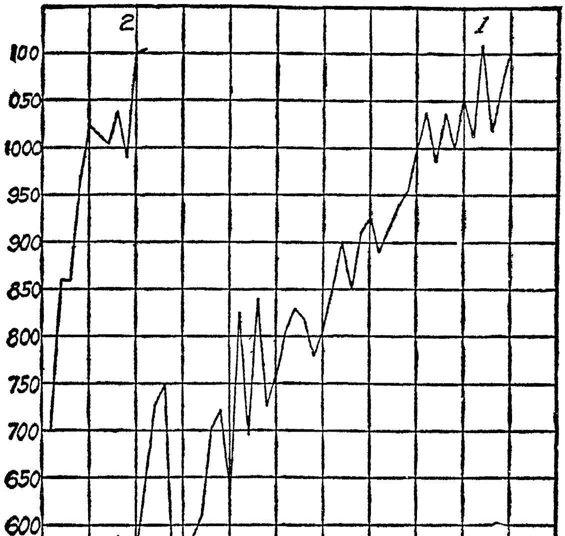

FIG. 24.—Curve of learning to write on the typewriter. The horizontal distance shows the days of practice; the vertical line the number of words written in an hour. Curve *1* shows the progress during the original practice; curve *2*, the results of nine days' practice after an interval of two years and thirty-five days. (From Swift: "Memory of Skillful Movements," Psychological Bulletin, vol. iii, p. 186.)

ments of a general character have been acquired and fully fixed as habits, the ability to act with greater skill and certainty is acquired by putting together old movements in new ways. This new adjustment also is largely dependent upon chance trial, although the chance trial may be hastened by rules as to what to do and also as to what not to do. In learning typewriting, for example, each of the separate movements involved has been learned long before there is necessity of applying it. Putting the different part movements together in the ways to give the greatest speed and accuracy, requires long practice. It is possible to formulate exercises, to teach the position of the key for each letter and to keep the eyes upon the matter that is written while making the fingers find the keys alone. Ability to follow these rules, and to make the movements in right succession with sufficient speed to justify employment is a matter of long trial.

Stages in the Acquisition of Skill.—The first step consists in the formation of the habit of combining the more common groups of letters, the "ing," "tion," etc. Later, phrases or even familiar sentences, may become units that can be started by one impulse and finished as units. All these habits with the wider adaptations that make it possible for the groupings to take place quickly are formed as a result of constant practice. The course of learning is very rapid at first and gradually slows down to what is practically a straight line. Probably no one ever reaches the absolute limit of efficiency. Most individuals do what is expected of them in a given situation and do not exert themselves beyond that point. If a printer who has not been able to do more than a given

amount after years of practice is suddenly offered a bonus for an increase beyond that amount he will in most cases show a great increase in the average amount accomplished per day. In the work of the average student, the same principle holds. He has hit upon methods that will satisfy the conditions under which he works and he does not struggle to increase his speed or accuracy farther and will not unless some special pressure is put upon him. Insistence or reward can always spur him to rise to new levels.

Plateaus in the Curve of Learning.—A feature of the learning curve that early attracted attention was the fact that there were nearly always periods of no gain during which the score remained nearly the same over a considerable period. Various explanations have been offered for these periods. One of the earliest was that during that time habits that were necessary for the later improvement were formed or confirmed. It is true that all learning can be pushed beyond the point at which the response can be made promptly and accurately. This extra learning or over learning has an effect in greater permanence of the material learned, although it may have no noticeable effect upon the immediate performance. The assumption is that improved combinations of movements can be developed only after the primary habits are thoroughly ingrained. This is probably one element in the plateau period.

Plateaus May be Periods of Relaxed Effort.—Again it has been suggested that plateaus mark periods in which no great effort is exerted and may be due to indifference or laziness. At least the converse is emphasized that the new period of improvement comes when

new and extra effort is exerted. This offers at least a partial explanation of the plateau, although again it is not all that is necessary. Effort may be too great, and progress may stop for considerable periods when the same effort is being exerted continuously. If one tries too hard before one is ready to progress to the next step in speed, the result is not progress but a slowing down of speed. If extra effort is exerted after the new habits are fully prepared for, improvement may result. The increased efficiency seems to be the result of hitting by chance upon some new combination of movements. And these new methods of approach come when there is extra effort and overflow movements which strike out into new channels. Usually one does not know what it was that made the difference. Frequently there seems to be no more effort just after the speed has increased, and it may seem easier than before. At times, however, when new incentive to effort presents itself there will be a sudden improvement. If the incentive or the effort is applied too soon, it may merely break up the old coordinations without producing any beneficial new combination, and there will be loss rather than gain.

Plateaus, Periods of Combining Parts Already Learned.—Still another explanation probably holds for certain cases. This is that during the plateau period certain partial connections are being formed, habits of connecting elementary movements in small units. When the rise appears, these smaller parts are being united in larger wholes. During the period when the partial units are being established nothing of the progress shows in the actual accomplishment, but it is nevertheless preparation for the next step which will be beneficial. It was

also shown that if attention can be distributed over the whole process, all parts may be improved more or less in the same amount and then no plateaus appear.

From the school point of view, it is well to remember that progress is not regular. That it will be very rapid when any operation is first begun and will become slower and slower, until finally no progress is made. This steady progress is interrupted by periods of no apparent advance, followed by rapid improvement. These are times in which the individual is preparing himself for the next advance. While one should not encourage them, should not permit the fact that they are known to exist to be an excuse for relaxation of effort, the teacher may well take them into account. They have been noticed not merely in all forms of motor acquisition, but in learning Russian as well, and so may very well appear in all forms of school work that involve learning.

The Control of Movements.—The third problem that we need to face is the way in which one makes movements once they have been learned. To answer this question we may go back to our first principle that action always follows upon sensory stimulation or the arousal of a sensory part of the cortex which is accompanied by idea. When one holds one's attention fixed upon a movement or the result to be accomplished, the appropriate movement is made at once. The intention to move largely consists of holding in mind the end to be attained. This comes only when the conditions are ripe for making the movements necessary to attain the end. A large number of physiological processes, many of which are unconscious, must coöperate to insure that the movement takes the course that it does. In any discussion

of the control of movement one must analyze these factors. The general principle involved is that an idea or sensory impulse determines movement and that if one can direct the sensory processes, the motor will take care of themselves.

The Initiating Forces and Incentives.—Almost any stimulus that acts upon the individual while a movement is being executed has some effect upon the course or character of the action. For purposes of discussion, they may be divided into the antecedent mental and physiological processes, the accompanying and the succeeding states. The first group may be again divided into the immediate occasion, the context or the larger setting of the moment, and the forces of a more incidental character that determine the degree of effort. The idea that starts the movement is any idea that has become connected with the movement in the past. When the movement is new, a more or less definite picture or feeling of the movement may constitute the cue. After it becomes familiar, the idea of the end to be attained suffices to incite to it. It is even doubtful whether one ever has a picture or the feeling of the movement to be executed. Possibly when a movement seems difficult the hand is pictured in the position that it should occupy to execute the movement, or there is a memory of the way the member would feel while it was making the movement. While this will at times lead to the execution of the movement, it is by no means certain that every movement that one imagines will be executed.

Idea of Movement at Times Checked by Another Idea or Circumstance.—The difference between having an idea of a movement and having the intention of

making it has been much discussed, but no very definite criterion for distinguishing them has been developed. The setting in which the individual is placed is important, as is the attitude that he takes which results from the setting and his appreciation of it. One may think of getting up in the morning and have nothing happen, even if one pictures the results that are to ensue upon continuing to remain idle. Suddenly one may find one's self getting up without knowing why. This may be due to the removal of inhibitions. Some of the forces which have been checking the tendency to movement lose their force or drop out. The others that tend to produce the movement have their natural effect and we act.

Idea of Goal a Frequent Initiator of Movement.—The idea in mind when the movement results which may be presumed to represent the activities that induce the movement becomes more and more schematic with the repetition of the act. Towards the end, the object which is to be manipulated in some way which is the end of the movement alone needs to catch attention to have the familiar movement executed. Usually the object catches attention only after the end of the movement has been thought of more or less definitely. It is usually only one link in a series of mental operations that has led up to the act. When one writes a word or a sentence there has been a thought of what has to be written in general that leads to the whole task of formulating a letter or a lecture or a book; the particular sentence suggested grows out of the context and what has gone before, in the attainment of the general end. Where the particular operation is as habitual as is writing, no idea of particular act needs to precede. Each move-

ment is started by the one that has gone before, guided by the general notion of what is to be said. At each of these stages, the idea that immediately evokes the movement may be of the most schematic type. It is the whole train of events, physical and mental, that must be regarded as the occasion for the act.

Control by Relevant Visual and Auditory Sensations.—The movement is controlled in direction and in strength by a number of incidental forces or factors. Immediate direction of the movement is by the eyes. Sight of where the member is at the moment before the movement starts and the place at each point in the movement serves as a constant guide. When the hand is seen to depart from the movement intended, as from a guiding line, an impulse is sent out that brings it back at once. This control is exerted in all movements of writing, of artistic performance, and all movements in games that are not too rapid to be modified during their course. The ear exerts a similar influence upon the quality of the voice in speaking and singing and upon the bowing of the violin. The first production of the tone is by chance and it is then adjusted until the ear is satisfied with the effect produced. There is also in many cases a control exerted by the sensations that come back from the moving muscle. These give information as to the position of the member when the movement is started and make certain that each subsequent movement is accurately made.

Many Incentives Unnoticed.—Many incidental stimuli contribute to determine the force and direction of the movement. The speed of running is much greater in competition than when merely running against time with no one to set the pace. The work done in pulling the

maximum against a spring was increased markedly when a goal was set just beyond what had been the highest point that had been reached. In a race a moderately near goal spurs to greater speed than a very distant one, or than a very near one. The greatest unit speeds are made in the 100 yard and 220 yard dashes. The mere interest of seeing the water splash spurs a gang of laborers to greater speed in shoveling earth. Contractors say that men will do fifteen per cent more work when throwing the earth into water than when throwing it on dry ground. All of these act without the knowledge of the individual and without the presence of conscious effort. They represent the contribution of other stimuli and sensations upon the initiating impulse. Some of their influence is due to instinctive connections, some to habits.

The Wider Control of Action.—Before the action is made, there must frequently be a decision as to what line of action to follow. It is frequently necessary to choose. Choice between acts is usually choice between ends to be attained. When the end is chosen, the means to attain the end are nearly always suggested at once. In making the choice of ends, practically all of the factors that we have considered as controlling attention are brought into play. In fact, the selection may be pictured as depending upon placing attention upon one end rather than another. Certain of the ends will be pleasant because they appeal to instincts, others because they are habitual, others again because they are approved by the group in which one lives, are favored by social pressure. Where the approval is by the ultimately best group, the group one believes to have the broadest and most enlightened outlook, we usually identify this

with our own ultimate good, and call the total set of forces that lead to acceptance of that goal and force to the acts that will attain it, our conscience.

Higher and Lower Ends.—Frequently we oppose the instinctively pleasant and habitual acts to the group that is determined by social approval, as an opposition of our higher and lower natures. This is not necessarily a true classification as the instinctively pleasant acts are most of them good provided only that the time and place are suitable, and desirable habits may certainly be developed provided only they are taken in time. The reason for the opposition in general usage is that the good instincts are strong enough to take care of themselves, while we frequently need to strengthen those which depend upon social pressure. In fact, were those favored by social pressure strong in themselves, there would never have arisen any occasion to employ social pressure to reinforce them. In making a decision, then, we are simply attending to one or the other of the two ends. When both are attractive, they may alternate before the mind until we can find some rational advantage in one or the other. When it is seen that one promises greater advantages than the other, that is firmly held before us and the other is rejected by the same fact and act. After the end is chosen, the appropriate act will follow immediately through habit.

Training Volition.—What is ordinarily called training will can be accomplished by taking advantage of a knowledge of the factors that lead to decisions. One can obviously form good habits. These may attach not merely to the detailed and particular activities which are involved in each special form of learning, but may

be extended to include more general forms of response. Under the head of more general habits are many that are usually regarded as character traits, perseverance, or not giving up in difficult situations, good methods of work in learning, reading, and other processes that are of general application. One may even form habits of not giving way to emotion, or of cheerfulness, although of course there are wide differences in the natural connections due to the distribution of the instinctive tendencies upon which they depend. These natural predispositions will be overcome only partially by later training.

A wider method of training will that can be exerted in the schools is in making the child accept a certain group as his own. By this he is brought under the influence of the ideals of that group. It is only as an individual can be made to feel that he belongs to a class or community that he will appreciate the necessity or desirability of accepting the standards of the group. Without this nothing can be done with him in the way of discipline, with it anything can be given a natural appeal. The standard of the school community can be directly enforced upon him. This implies giving the school group a definite status and also in making the group adopt a high set of ideals. This may itself require much tact and continuity in the school group for a considerable time. It is impossible to give rules for changing the ideals of a group that can be trusted to work universally. If they can be developed from within, there is least difficulty and they are most likely to be accepted. Rules help if started early and no exceptions are made. Example, where opportunity is given to offer

an example, is important and no progress can be made if those in authority do not themselves follow the rules that are set or the ideals that are preached. Aid may be obtained from instincts if one can devise forms of rivalry between groups in matters that will involve ideals.

Incentives that May be Applied in School.—The problem of the control of action appears in the schoolroom in the form of inducing work and in preventing disturbing or destructive acts. Both, of course, presuppose a good group spirit to which one may appeal. Obtaining the maximum work implies not merely continuous effort, but effort well directed. It has often been observed that progress in real school work is usually much less marked than in the special experiments to determine the rate of learning. Certain of the incentives that are used in the experiments might very easily be applied in the schoolroom. One that is important is to know the rate of progress. If one can apply any of the measures of progress that have been developed for the different school subjects, one can give each student a notion of how successful he has been, and this knowledge of itself will afford a measure of progress and in most cases a stimulus to effort.

Pointing out the errors that are made and the departures from the best methods is also of aid. One improves much more rapidly if one knows exactly where the source of error lies. Study of each of the processes involved as they are applied by each individual student will enable the teacher in many cases to point to the element which is not being used in the most economical fashion. The student can then apply his effort to the improvement of that particular phase. It will be possible to improve

much more quickly than if improvement is left altogether to chance. One can also, at times, introduce team rivalries that will spur to more effective action. Group rivalries, through the appeal to the social instinct, are more effective than individual ones alone.

Voluntary Control and Discipline.—Certain of the laws for the control of action can be applied to the development of discipline. Undesirable actions should always be connected with unpleasant results, desirable acts with pleasant. Whatever punishment is applied should be applied without exception and as promptly as possible. The modern rules limit the punishments that can be used to unpleasant tasks and holding up to social disapproval. These are probably the most effective that can be used, more effective than physical pain were its infliction permitted. Certainty in punishment is more important than severity. A fine of three marks imposed without exception by the policeman who detects the offense is more effective in Germany in preventing individuals from walking on railway tracks than the danger of being killed which does destroy one in every ten thousand offenders in this country.

Have as few prohibitions as possible. Give rules as to what should be done. Never say "don't" except when the specific act has been or is about to be performed. To prohibit is to suggest. The best discipline can be exerted by keeping the students so busy that there is no time for mischief or undesirable acts.

Voluntary action, then, is the expression of the control of habits and ideals upon the acts of the individual. The action results from the idea of a movement, and the idea that will be favored is determined by all of the

factors acting upon the individual at the moment, as well as the instincts and earlier experience, particularly the reactions with the social group. The force and accuracy of the movement depend (1) upon sensory stimuli which act upon the individual during the movement, (2) upon memories of older experiences, and (3) upon ideas of acts to be made. The sum of the acquired and inherited tendencies of the individual towards actions constitute what we call his will.

Writing as a Form of Action.—Each stage of the movement process may be illustrated by the development of writing. With the child it begins as a process of trial and error. The separate movements have been already developed in other connections, but it is necessary to put them together in new ways to write well. Many directions can be given by the experienced teacher that will aid the trials. The child may be shown how to use the arm movement, and can be shown the most effective slant. All movements that produce unsatisfactory results can and should be detected and checked before they develop into habits. It is better to have a model written before the child, than to have a copy given him with the mere suggestion that he imitate it. Otherwise the laws of trial and error hold. He must hit upon the movement for himself, he cannot be helped by having his hand put through the movements.

Habits of Good Writing Should be Without Exception.—One of the main defects in the teaching of writing is that the writing in other class periods may not follow the rules laid down during the special period. A child may be taught the arm movement in the time devoted to the writing lesson and then be permitted to write as he

pleases in all of his other exercises. Obviously the drill of the few hours a week given specifically to writing will be overcome by the much longer practice on bad methods. Even the quality is not kept up to the same standard in the regular work as in the special period as it should be if real progress is to be made. A questionnaire sent to men and women graduates of the public schools who were earning a living by addressing envelopes showed that although most of them had been taught the arm movement in school, the great majority used a finger movement in their actual work. Obviously that training had been wasted. It is possible to supervise the ordinary writing of the child and see to it that the rules taught are applied to the general work of the school.

Writing furnishes a very good illustration of the control effects of the eye and the sensations from the muscles. When the pen is seen to be departing from the line it is at once brought back, and when the pen is not tracing the form that is seen in the copy or is imagined, correction is at once made. The writer may not be aware of the influence of the eyes in writing, but if he closes his eyes, he will begin to write with great inaccuracy. The sensations from the hand and arm will also aid in controlling the movement. These are even more difficult to demonstrate. When they have been destroyed by certain diseases, it will be noticed that the movements are much less accurate than usual, but their presence is not noticed.

The Initiation of the Writing Movement.—The writing movement is first made in response to some idea of a specific movement. What this is varies with the individual, but probably in most cases it is some definite image

of the letter or line to be made. With practice this specific image drops out, and the mere intention of writing a letter or a word is all that is necessary to start the movement. In the practiced adult the mere thought of the word with the appreciation that it is the time to write is sufficient. The student begins to take notes with little or no decision. He may write while thinking of something else. When any definite intention precedes, it is probably nothing more than a vague thought that the particular topic may prove to be important. With that the whole movement starts.

QUESTIONS ON CHAPTER XIII

1. What starts all action?
2. Distinguish between a reflex and a voluntary act.
3. How are new movements learned?
4. Can you learn to wink the left eye without the right? How?
5. How do you acquire skill in a complicated act?
6. Outline certain characteristics of the course or curve of improvement.
7. Explain the plateaus.
8. What influences control a movement, once it has been learned?
9. How do you make a tennis or golf stroke?
10. Is there an independent will? If there were, what would be its limits?
11. What guide to the discipline of a school does the psychology of volition give?

REFERENCES FOR CHAPTER XIII

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CHAPTER XIV

THE NATURE OF FATIGUE. FATIGUE IN SCHOOL WORK.

Importance to Teacher of Knowledge Concerning Fatigue.—Much attention has been given in recent literature to the question of the nature of fatigue as well as to providing means of reducing it as much as possible in the pursuit of any occupation. For the teacher the study is supposed to be valuable first in determining when or if a student is working beyond his strength and secondly in seeking an arrangement of the school program which shall permit the accomplishment of the most work with the least fatigue. Obviously one might desire to know how to measure the effects of work upon the child in reference to his decreasing capacity for work, to be able to say if a particular child were working too hard and if possible to devise a daily regimen which would enable him to do the same work with less fatigue.

Definition and Detection of Fatigue.—The general problem of mental fatigue must serve as a beginning in the discussion. An accurate definition offers some difficulties, for fatigue is not a state that can be seen for itself, nor do we have any consciousness that regularly accompanies it. Possibly it may be provisionally defined as a diminution in the capacity for any function that comes as a result of an exercise of that function. This definition suffers under one possible limitation from

the fact that fatigue need not necessarily show in the actual output, because, after use, increased incentive may serve to keep the individual working harder and so lead him to keep up the output at the expense of greater effort. We might well say that the function was fatigued although no evidence of it appears in the result. The only effect is to be seen in the fact that the point at which work must stop is brought measurably nearer by the previous work or in the feeling of greater effort or other bodily sensations which accompany the work.

Is Fatigue Real?—We should need to modify our definition to say that fatigue is the decrease in ability to accomplish the same amount with equal effort, or possibility by the statement that fatigue is progress of the individual towards the point where a given function will cease to be available. The idea that lies back of the notion of fatigue is that there is a limited capacity for work in each respect and that any exercise of a function serves to draw upon that sum total of energy until it is exhausted. This picture of the nature of human energy has been contested. In fact, present opinion as to fatigue seems to be divided into two camps. One insists that there is no such thing as fatigue; the other that you can be fatigued without knowing it. Thorndike, who represents the negative side, argued from some experiments a few years ago that there was no mental fatigue, that one might become bored and not work so hard, but could always work as fast and well, provided only one cared to. Dodge, also on the basis of careful experimental work, argued on the contrary, that one was always becoming fatigued whenever work of any kind was being done, but that the effects were usually concealed under the greater

effort that was brought out by fatigue. One might exaggerate the two theories by saying that the one insists that you never tire mentally, the other that you were always in the process of tiring but did not always know it.

The Nature of Muscular Fatigue.—Evidently if we are

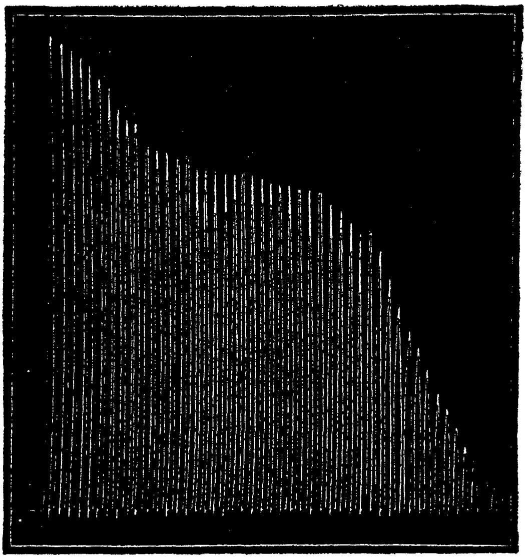

Fig. 25.—The vertical lines indicate the relative distances through which a weight of 6½ pounds is pulled by the middle finger of the right hand. Contractions were made at intervals of two seconds. (From Howell's, "A Textbook of Physiology," 5th Edition, p. 48.)

to be able to come to close quarters with the fatigue problem, we must attempt to discover its physiological conditions as well as its effects in action. First, what is the nature of fatigue as a physical process? On the side of physical or muscular fatigue, we have considerable evidence of the nature of the process. Early experiments by

Mosso and others showed that an isolated nerve-muscle preparation could be fatigued by continued contraction until the contractions ceased to occur. It was found that the seat of the fatigue in this case was first at the point of connection between the nerve and the muscle at the muscle plate. This was evident from the fact that after the whole preparation had ceased to respond to stimulation, one could still excite the muscle by applying the electrode to the muscle itself. It could also be shown that the nerve fiber was still capable of conducting an impulse, in fact we have reason to believe that a nerve fiber, even an isolated nerve fiber out of the body and so not supplied with its regular nourishment, never fatigues.

The Seat of Motor Fatigue.—The muscle on the other hand may be fatigued. For if one will continue to apply the electrode to the muscle directly for a long enough time, the muscle will cease to respond. The fatigue of the muscle may be shown to be due in this case to the presence of products of work which accumulate in it. These may be dissolved in a weak solution of salt-water and, when they have been removed by washing, the muscle will respond again as before. Whether there is a possibility of fatiguing the muscle to the point where its store of nourishment is altogether exhausted is as yet unknown. Certainly the first fatigue that is noticed is due to the presence of accumulated products of fatigue which act as poisons to diminish the capacity for response. These poisons have also been shown to be present in the blood in sufficient degree to affect the capacity of the general musculature of the body. It would seem then that fatigue is in certain cases due to the presence

of products of work in the muscle and in the blood which prevent the individual from working to full capacity.

The Nerve Cell in Fatigue.—In the central nervous system we have observations which indicate that there is an actual exhaustion of the substance which may prevent the further activity of the elements. The nuclei of neurones of bees at the beginning of the day are full and

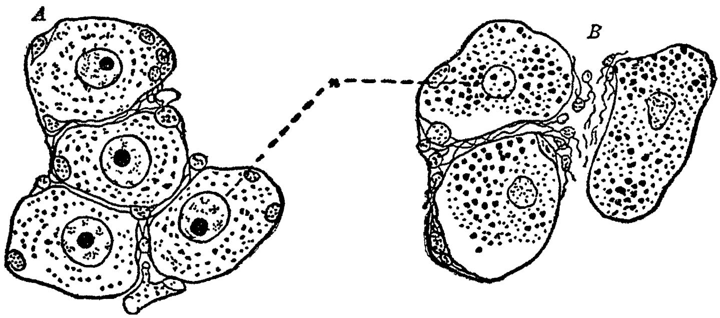

FIG. 26.—Changes in the nucleus as a result of fatigue. (*A*) and (*B*) are both from the spinal ganglion of a cat. (*A*) shows the resting condition, (*B*) a cell after electrical stimulation of its nerve for five hours. The nuclei in (*B*) may be seen to be much smaller and to be very irregular in outline. (From "American Text-book of Physiology," after Hodge.)

plump in appearance. After returning from a day's work gathering honey, the nuclei will have been so reduced in size as to be rather flabby in appearance. There are then three places in the body at which work of a muscular type can be shown to reduce the capacity for action. The first is in the muscle where we may ascribe the effects to the presence of poisons or of waste products that act as poisons, the second is at the point where nerve joins muscle, the end plate, the third is in the nerve cell proper; the nucleus shrinks with the performance of work.

The Order of Fatiguing of Neuro-muscular Mechanisms.—If we turn from the isolated muscle to the muscle and nerves in the living body as a whole we can draw some conclusions which indicate that many of the laws are identical with those offered by the tissues in isolation. Experiments with an isolated movement, a movement that so far as possible involves a small group of muscles, show much the same course of diminution in work as in the isolated muscle. The end-plate seems to fatigue first, for an electric stimulus will arouse contractions in a muscle that is apparently completely exhausted. Between the muscle and the central nerve, no decision has been made, but the balance of opinion indicates that it is probably the muscle that is primarily responsible. In work of this kind, however, the effects of fatigue do not show themselves as a continuous and regular diminution of response. In fact the first effect is usually to increase the response of the muscle. We have reason from the action of isolated muscles to believe that the first effect of the accumulated waste products is to increase rather than to diminish the response. When present in diluted solutions they increase the irritability of the muscle and produce a larger contraction. Then too the muscle is not uninfluenced by the connection with the nervous system as a whole. Even if one is trained to give always the same amount of response, it is not possible to avoid spurting at times, and this will give increased contractions that may interfere with the smoothness of the curve. We have shown that the amount of work that will be done is increased by anything that acts as an incentive to activity and that even when the incentive is extremely slight. The fatigue is

not merely an expression of the chemical reactions in the muscles, even including the influence of waste products upon the muscle, but mental factors of various kinds also have an influence in determining the amount of contraction.

Physical Changes in Mental Fatigue.—When we ask about the nature of mental fatigue from the standpoint of the organic changes we have only indirect evidence. Of course all mental work has an effect upon the muscles indirectly, but probably it is seldom if ever sufficient in the intensity or extent of the movement to create real conditions of fatigue in the sense of either accumulation of poisons or exhaustion of the stored nourishment of the muscle. Most of the physical effects must be ascribed to the changes in the neurones of the nerve centers involved. Whether there is real exhaustion here has been questioned by Lee, who, working with Thorndike, came to the conclusion that there was no fatigue of the nerve centers, no use of the substances of the neurone that would not be compensated for by the nutritive substances drawn from the blood as the tissue of the cell body was oxidized. A negative conclusion of this kind cannot of course be final in the present state of our methods of experimenting upon the central nervous system. We must look for indirect evidence.

Changes in Metabolism During Mental Work.—As to the effects of mental work upon the bodily metabolism as a whole, results differ greatly. Atwood with his calorimeter could detect no increase in the heat output of the body during mental work over that when the individual was resting as completely as possible, while he found very marked effects to accompany muscular

work. Dodge on the other hand tested the effects of hard mental work upon the circulation and found that it had the same effect as lifting a heavy weight. The Atwood method was probably more direct, but the work was of relatively short duration and the experiment was not frequently repeated. We might argue that even the ordinary thought processes always and unavoidably produce a certain effect in the bodily metabolism and that an attempt to do hard work does not markedly increase them. The Dodge method would have the advantage of measuring the effects of shorter periods of work. The circulatory effects may be noticed almost immediately, while changes in the output of heat would not be measurable except when the work extended over a considerable period of time.

Changes in Circulation in Fatigue.—More specific effects of long continued work seem to indicate bodily changes. Mental work has been shown by Griffitts and the writer to decrease the blood pressure when continued for two hours. Lewis found that there was an increase in the amount of adrenalin in the circulation as work was more prolonged. This would probably be an automatic protection against the effect of fatigue since adrenalin serves to increase the tonic reaction of the organism. There may be changes in the cortical cells, there may be the same accumulation of fatigue products as from physical exertion. Piéron has obtained evidence that sleep may be due to the development of a toxin in the blood, and mental work has the same general tendency to produce sleep that physical work has. While not conclusively established, the evidence indicates that mental work has definite physical accompaniments that are

at least similar to the results induced by physical work.

The Curve of Work.—Studies of the actual course of work over periods of different length indicate that the changes in the amount of work done and in the quality of the work are relatively slight. The changes include both increase and decrease in the work done. Kræpelin

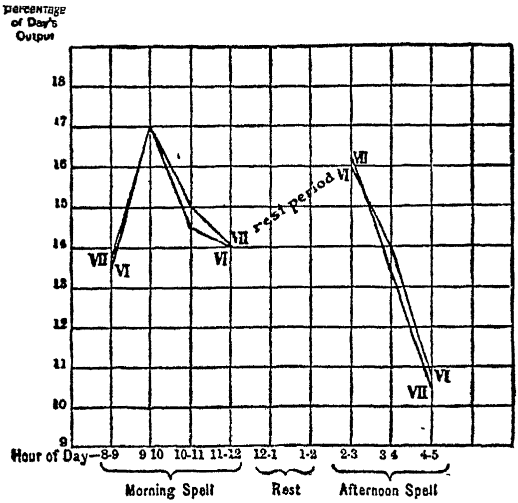

FIG. 27.—Shows typical distribution of output over the working day. Work of Italian typesetters. (From Muscio.)

in 1904 analyzed the forces that determine the course of work into five. Fatigue which diminishes capacity, and practice, inertia, habituation and special incentives or will which increase it. Fatigue is assumed to begin at once, and, if not obscured by the other influences, would produce a constant decrease in the amount of work accomplished in a unit of time. Practice on the other hand tends just as constantly to increase the amount

of work done. Each bit of work heightens the efficiency, at least for a considerable period of time. The effects of practice continue for a long time even when no more work is done, while the effects of fatigue are relatively transient. Habituation means becoming accustomed to the surroundings of the experiment. This serves to increase the efficiency by making the individual feel at home. It lasts for a considerable period also. Inertia is a force very much like the same tendency in a physical body. When one is started on a piece of work one gradually increases speed up to a certain point and can go on more readily than one could at first. If one stops for even a brief period one loses momentum and can reach the same efficiency again only after again getting up speed. The special incentive makes its appearance usually both when work begins and just before the end. It is what we call popularly the force of will, the result of a special desire to do one's best. Figures 27 and 28 herewith show how the amount accomplished in a factory and the number of accidents at different hours of the day follow the curve of fatigue.

The Components of the Curve of Work.—The action of these different factors taken together produces the curve of work. Or, put in the way they were actually derived, the course of work which gives rise to the assumption of these different components, is first a relatively sharp decline. This decline is mainly due to the fact that the worker is inclined to start with great determination to do his best which results in an accomplishment at first above the normal level. Effort does not continue long so there is a relatively sudden decrease in accomplishment as the incentive is relaxed. After this

point there is a long rise through the growing practice, habituation, and inertia. This rise continues for a time that varies with the difficulty of the work and the effort expended. Then a decline may begin, as fatigue predominates over the beneficial factors. Just at the end there is what is known as the terminal spurt. As the

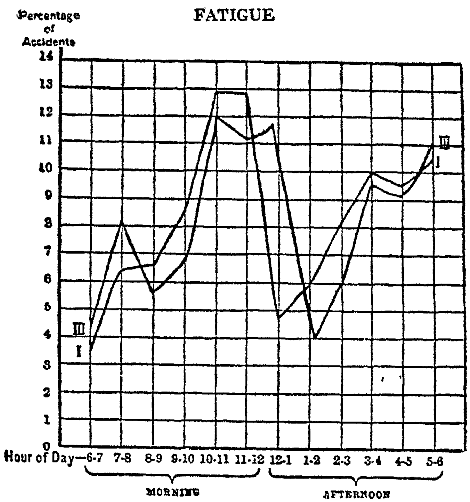

FIG. 28.—Shows the time of occurrence of industrial accidents, I in Germany in 1887, III in Lancashire, England. It will be noted that the periods of increased output are periods of small number of accidents and *vice versa*, by comparison with Fig. 27. (From Muscio.)

worker sees that the end is approaching he exerts more effort to make up for any early laxness and so increases the amount of work accomplished.

Effects of Rest.—If a rest period is introduced, such as a recess in school, and work begins again, there is usually a slight increase at first through the initial spurt, then again after that has been succeeded by the fall

after the passing spurt, a slight rise due to inertia and practice appears. Whether the immediate effect is up or down depends upon the degree of fatigue and the duration of the intermission. If fatigue is great, the beneficial effects will be more pronounced than if the fatigue is less. Again if the intermission be too long, one may lose more from the decreased inertia than is gained by recovery from fatigue. The more difficult the work, the more frequent and the longer should be the intermissions. Young children cannot be expected to work long without breaks. Obviously more experiments are necessary before we can make definite statements about the length of the rest period that is best in each set of circumstances. For adults doing mental arithmetic it was found that one five-minute interval in a two-hour work period gave the most satisfactory result. The general principles stated above may be effective as a general guide for practical trials. Friedrichs working with school children found a much smaller number of mistakes if an eight-minute recess was introduced between two class periods of an hour each than if one followed directly upon the other. When there were three hours of work, a rest of fifteen minutes after each hour gave a marked decrease in mistakes in dictation as compared with no rest and also as compared with only one rest period. If only one rest period were to be introduced it was better to have it at the end of the first hour rather than after the second.

Rest Periods in Manual Work.—The importance of frequent rests in severe manual labor has been demonstrated in many industries. One of the best known instances is seen in the case of men who were to wheel

heavy loads in barrows up an inclined plane. When left to themselves they would not take sufficient rest and in spite of the offer of a bonus for exceeding a minimum, at first, none of them could attain the minimum task. Later a foreman gave a signal and the men were required to rest for three minutes after each twelve minutes of work. The second day after this procedure had been adopted all of the men were doing more than the minimum, and on the third day the average pay had risen to 40% more than the miminum, which none had been able to attain before the rest had been introduced. In a number of cases in industry it has been found desirable to introduce compulsory rest periods in carrying out heavy physical work. In driving rivets it was found that when the riveters were compelled to rest two minutes after each 10 rivets, a task that required about 1¾ minutes, the number of rivets per day increased from 600 to 1600.

Little Evidence of Fatigue in School Work.—When we turn from the results of experiments and their theoretical discussion to the more practical application, it seems that for the normal individual working no harder than is required by the ordinary school work, the effects of fatigue are unimportant. The effects of incentives and inertia more than overcome the effects of fatigue during the usual school day. Gates found that if he measured the capacity of the child by his accomplishment in working arithmetical problems, marking out letters and in different types of memory tests, that there was a gradual increase in the amount of work for each hour of the school day after the first. The only exception was found in the first period after the noon recess, during which certain tests showed a loss and others little or no

gain. Gates asserts that ordinary school work is not severe enough to produce any considerable fatigue. The only conclusion that he draws is that the first period in the afternoon should be used for the relatively easy subjects.

Young Children Fatigue More Quickly.—Winch applied a slightly different test to the same end. He used as his measure of fatigue, not the accomplishment at different periods, but the relative increase in rate and accuracy of solving arithmetical problems during a series of tests. He applied the tests to children of different ages from the earliest at six to seven, to both boys and girls of thirteen or fourteen. His results agree with Gates' in showing that there is little or no demonstrable fatigue for the older children induced by the work of the school day. They improve, on the average, just as much in the work performed at 3:30 as at 9:00 in the morning. The younger children, on the contrary, show decidedly the effects of fatigue. There is during the last school hour a decrease, rather than an increase due to the practice effect. Winch concludes that training is absolutely useless for children of from six to seven years at 3:30 in the afternoon after a day in school. Fatigue is too strong to be overcome. Ten-year boys showed a slight effect of fatigue. Boys of thirteen almost none at all.

It would seem that for practical school purposes the amount of fatigue induced by the ordinary school work is almost negligible for the older children. It may be detected with the very youngest. Of course, too, it is possible that one might need to make exceptions in this statement in case of the feebler or more nervous children. They would form special cases and must be considered

as such. More is made of it in Europe where, undoubtedly, the school discipline is more rigorous and more strenuous work is demanded of the students at all ages. Even here the adjustment of work to produce the minimum of fatigue may be desirable for the weaker individuals, or for exceptional cases.

Fatigue and Boredom.—The relation between fatigue and lassitude or boredom has been much discussed. Thorndike, as was remarked, has insisted that boredom is the only real cause for diminution of work; while fatigue has no real existence. It is still too soon to decide definitely on this point. Certain it is that disinclination to work is frequently the first effect of work, particularly of monotonous work. Probably it is the most frequent occasion for the cessation or slowing up of work in the ordinary school. Even this should be avoided as far as is possible by making the work interesting and by changing from one type of work to another. It has been shown that physical work which is interesting is less fatiguing as measured even by the amount of work that can be done after a certain point has been reached than is monotonous work. Here the interest consisted merely in setting a goal to be reached in pressing a spring downward with the thumb. The uninteresting work consisted merely in pressing as far as possible without any definite goal. In mental work, also, one will work very much longer and with greater application when interested than when merely working against time. When writing a thesis that is interesting, or finishing a piece of constructive work one will work far into the night with little apparent decrease in capacity. When the work is uninteresting, no matter how pressing the de-

mand that it shall be done, fatigue or unwillingness to work begins early and one takes the first opportunity of an excuse from the need of eight hours' sleep or other hygienic rule to stop.

School children, in the same way, will continue with work in the form of a game, for a much longer time than they will spend on the same amount of learning that is presented as a part of the regular routine work. Not all work can be made interesting, and perhaps it is as well that the child should form habits of performing tasks just because they must be done. In after life he will be unable to avoid work of this kind and he should be in a measure prepared for it by the work of the school. That should not be taken to mean that tasks should be made monotonous for the sake of discipline. There is always enough work that must be uninteresting in every curriculum to furnish all of the discipline needed. All that will be necessary is that the child be not excused from necessary tasks merely because he finds them uninteresting, after all possible has been done to give them an interesting form. This will develop the habit of doing essential work without asking if it is interesting.

Signs of Fatigue.—Fatigue bears little necessary relation to the feelings of fatigue. These may be very much related to boredom. Mental fatigue is frequently accompanied by physical movements of different sorts. These give rise to sensations from the member and in the mass may give the impression of fatigue. The disinclination to work may be noticed directly. Neither sign is of very high predictive value. Many times when the individual feels a marked disinclination to work he may be

able to do work above the average if only he will make the effort. On the other hand, special excitement may make a man feel capable of good work when he has already worked more than he should. In this case he will likely be able to work well, although at the expense of a sleepless night afterwards and possibly a bad day following. One can only decide in terms of past experience as to the after effects of work under the conditions in question, whether the sensations and other signs indicate real fatigue or are fallacious. For adults the interpretation must be left to the individual. Usually, and possibly fortunately, decision is more likely to be made in terms of the established routine than by sensations. Even if one is not bound by rules of any type, one is pretty sure to form habits of work and to devote set times to work of each kind and to have other regular periods for recreation.

Fatigue a Safety Valve.—The function of fatigue or boredom is to save the individual from too great exhaustion. It appears before the danger point is reached in practically every individual, in some much before, in others only as the point of exhaustion approaches. Whether we are to regard the sign as real fatigue or merely as boredom matters very little for practical purposes. Those who believe in the reality of fatigue admit that the signs so far as they are represented in sensation are frequently ambiguous. They appear almost as often when the person is still capable of excellent work as when he has passed well beyond the maximum.

The great difference in the two schools is that one believes that the individual never works to the point of exhaustion, that his fundamental capacity for work is

never reduced by mental work and hence that feelings of fatigue are always fallacious. The other school, while admitting that signs are deceptive, in so far as one is capable of working with unreduced efficiency much after the sensations of fatigue become well marked, still believes that there is a reduction in the organic capacity as work goes on. There is evidence that the slight decrease in the work actually done, even over a comparatively long period, is due to the fact that, under incentives, there is an increased effort that compensates for the waning power. As in physical work, it is possible that the signs and effects of fatigue itself serve as a stimulus to effort, as the first effect of waste products upon the muscle is to increase its irritability. The sensations of fatigue spur to increased effort, just as distraction incites to greater attention.

Mental Exhaustion Possible.—We have evidence that after mental work is continued long enough there comes a time when work is no longer possible. Painter reports that when, after a hard day, he tried to do mental arithmetic from 11 p. m. to 3 a. m., he suddenly reached a point where he could do no more. Even when he changed to easier problems he could not succeed in any of them. Dodge reports similar experiences with eye-muscles. He could move his eyes up to a certain point with no indication of fatigue either from decreased rate or irregularity of movement, and then movement stopped suddenly. He could not move them at all. If this be true, we would have what we find, that the course of work shows relatively little decline as the task proceeds. There is a real decrease in amount of available energy, if we may use a loose term, but practice, inertia, and

other facilitating processes overcome the effects at first, and then as these lose their effect, extra effort comes in to keep the output up almost to the normal. Very late, after the work has been continued far beyond the point where work usually stops, there comes a point of complete exhaustion. When this is reached no amount of effort is capable of producing more work. It comes suddenly and may end in sleep, or possibly merely in incapacity. Certain it is that this occurs only at a stage beyond that usually reached in ordinary work.

Means of Recovery from Fatigue.—A series of practical questions arises naturally in connection with the best means of recovering from fatigue. Two means are frequently suggested popularly: one is to change the nature of the work, the other to turn to physical exercise. So far as we have experimental evidence, neither is efficacious. Whether changing work does or does not result in reducing fatigue depends upon whether the work to which one changes is easier or more difficult. Change to work of the same difficulty has no effect; if the work be easier, fatigue is naturally less rapid. This holds of fatigue as such, based on the results of Kræpelin's students. There is or may be a noticeably increased interest in a change that reduces boredom and spurs to greater effort. This is temporary.

Physical and Mental Fatigue.—The same holds of physical work. The capacity for physical work is decreased by mental fatigue and also the capacity for mental work decreases as a result of physical work. One is in no condition for hard study after a game of football or a vigorous day in the open. The introduction of physical work even for a short period does not assist

recuperation. This does not mean that the permanent effects of physical work may not be beneficial. They are, in so far as exercise is essential to the development of the physical organism, which in turn is essential to the mental as well as bodily functions. If one is seeking the best means of resting from mental work, it is not found in physical work. It used to be thought that gymnastic work should be introduced when the student was fatigued. Experience showed, however, that the student did poorly in his gymnastic exercises when mentally fatigued and also that he did not prepare for his later studying by the exercises. If one desires to recover from fatigue, the best method is to do nothing, so far as that is possible. Sleep is still more effective if there is time and opportunity for it.

Work and Ventilation.—Closely related to fatigue in diminishing efficiency is the effect of bad air. Here again, the effects are slow to show themselves. One, according to experiments, can do as good work in a room too hot, too moist, or too dry as in a room that is at the optimum in each of these respects. The optimum conditions assume a temperature of 68, a humidity of 50 and 45 cubic feet of air per person. These results do not mean that ventilation may not be important, simply that under effort one adapts one's self to unfavorable conditions. Health, at least, demands good air, as is seen in the treatment that is given in tuberculosis and the improvement that weakly children show in open air rooms. As in fatigue, the normal individual automatically compensates for unfavorable conditions, within fairly wide limits.

Somewhat related to the effects of fatigue in modify-

ing human efficiency are the effects of drugs. If we accept the toxin theory of fatigue, the method of acting may be the same. Three drugs come within the range of the teacher's common observation, tobacco, caffeine, and alcohol. We are now accumulating sufficient experimental data to answer some of the questions that are frequently asked about them, concerning their effects upon mental operations. Of the drugs ordinarily used all have a depressing effect, except caffeine, which seems to be universally an excitant. One may make the general comment on the methods of experimenting with all three that it is necessary to disguise the drug so that the subject of the experiment does not know when he takes a drug and when he is given an inert substance. Overlooking this precaution in the early work led to many errors. If the subject knows what he is given and has an expectation as to the effect likely to be produced he will unconsciously exert himself to bring about the expected result and so impair the value of the experiments.

Effects of Tobacco.—The effects of tobacco on mental work are so slight both in smokers and non-smokers that the utmost precautions have been necessary to reach any conclusions. The last investigation by Hull shows a constancy of effect for both smokers and non-smokers. He tested the effects on heart rate; on steadiness of the hand; on the quickness of voluntary movement as indicated by the number of taps that could be made per second; the liability to fatigue, measured by decrease in rate of tapping during the first two hundred and the second two hundred taps in immediate succession; on the rate and accuracy of canceling "A's"; on the rate and accuracy of complex mental addition; on the rate of

reading isolated words; on auditory memory span, and on rote learning. This furnishes a relatively wide range of functions covering purely physiological, motor, sensori-motor, and higher mental processes. The experiments were carefully conducted to prevent any knowledge when tobacco was being smoked and when hot air was being drawn through a pipe in an odor of smoke from another man's pipe.

Smoking has Slight Effect.—The effects on the different functions were slight except on the physiological. The heart was noticeably quickened and almost as much with habitual smokers as with non-smokers. The tremor of the hand was increased very markedly for both groups, a tremor that persisted for at least an hour and forty minutes. Of the other processes tested, the speed of mental addition seemed to be increased for habitual smokers, although there was loss for a smaller number of non-smokers. However the accuracy was if anything diminished for both groups. The memory span and capacity for rote learning were impaired slightly but definitely in both groups, and the rate of reaction was very slightly slowed. On the whole, the effects of tobacco are to depress and to decrease the capacity, but very slightly. In this the results of most of the investigations that have been carried out carefully seem to agree.

The Effects of Alcohol.—Alcohol, also, contrary to much of popular opinion is a depressant. Experiments similar to those with tobacco have been conducted by Kræpelin and his students, Rivers, Dodge and Benedict, Miles and Hollingworth. The functions tested covered those mentioned above for tobacco and more isolated association processes. Aside from the heart rate all are

slowed from two to forty per cent. Steadiness and body control in general is even more decidedly lessened. Hollingworth carried out a long investigation on the effects of low percentage beer (2.75%) and found that the dilution had relatively little effect provided the total alcohol consumed was the same in both cases. Hollingworth's table is given below:

Tests	*Beer containing total of 40–50cc Alcohol*	*Beer containing total of 66–79cc Alcohol*
Pulse-rate	+ 8	+ 10
Steadiness	—68	—241
Tapping	— 7	— 13
Coördination	— 6	— 10
Color naming	— 2	— 7
Opposites	— 5	— 12
Adding	—10	— 15

The general belief in the stimulating effect of alcohol is probably to be ascribed to the relaxation of inhibitions. When cerebral control is eliminated in any way things are said and done that would not be under normal circumstances. This greater freedom, coupled, possibly, with reduced capacity for judgment on the part of the observers, if they have also indulged, probably accounts for the widespread acceptance of the stimulating effect of alcohol. The stimulating effect on the pulse of both alcohol and tobacco has been ascribed to the greater effort put forth to overcome the depressing influence. It may also be due to the depressing effect upon the vagus whose function is to inhibit the normal rate of response of the heart muscle.

Effects of Caffeine.—Extensive experiments by Hollingworth on caffeine indicate that it is an excitant for

both physical and mental activity. From two to six grains, the doses between which Hollingworth experimented, increased the muscular tremor, quickened the association and motor processes and also made the association processes more accurate. Typewriting and adding were both quickened and the accuracy was increased, as was the efficiency of naming colors, and giving opposites. As the ordinary cup of black tea contains 1.5 grains of theine, identical with caffeine, and a large cup of coffee about 2.5 grains it will be seen that these beverages will have a definite effect. Larger doses as is well known produce sleeplessness. The effects of caffeine last from three to seven hours. There seems also to be no decided reaction for a period of forty days at least afterwards.

QUESTIONS ON CHAPTER XIV

1. What does it mean to fatigue a muscle?
2. At what points would fatigue of a muscle nerve preparation occur?
3. What changes occur in the whole organism as animal or man becomes fatigued?
4. Would any of these same processes be present in fatigue as a result of mental work?
5. Enumerate the factors influencing the course of work according to Kræpelin. What is the final shape of the curve?
6. Draw for comparison the curve of output in factories. The curve of accidents for different periods of the day. Would these be explained at all by the course of mental capacity?
7. To what extent does the work of a school fatigue the child? Draw the curve according to Gates.
8. How does fatiguability change with age?
9. Of what value is fatigue to the organism?
10. Is mental exhaustion possible?
11. How is fatigue related to boredom? Does interest affect the amount of work that can be done?
12. Give rules for recovering from fatigue.

13. What effects would a half hour's smoking have upon preparing a lesson?

14. Outline the pros and cons for smoking limited only to efficiency of study. Are other factors to be considered?

15. Describe the general effect of alcohol upon mental functions.

16. Why do tobacco and alcohol increase the heart rate?

17. How would the caffeine in a cup of coffee influence the evening's lesson?

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CHAPTER XV

TRANSFER OF TRAINING OR THE PROBLEM OF FORMAL DISCIPLINE

Improvement through Training the End of Education. —This problem of the possibility of changing the entire or a large part of the character of the individual by giving him an education is one that looms large in all educational discussion. To some the main justification of the present work of education consists in its effects in improving the individual as a whole and in all of his capacities for future work rather than in the acquirement of particular knowledge or particular skill. To these men, talking in the large, the advantage of education is that it prepares a population that has not been capable of much for great attainments. It is said, for example, that were the Russian people only educated the problem of self-government would be much simpler for them, although the possibility of ruling them from above would be much lessened. More specifically the question is asked and usually answered in the affirmative as to the possibility of improving a certain function by exercising some other particular one. The larger question may be put over until we ask the more particular one. Can one improve the individual in some one capacity by training him in another process that goes under the same general name? Thus it is popularly believed that a man has a memory and that any exercise of a memory function

trains all other phases of that function or capacity. The same would hold for reasoning and possibly for perception or discrimination.

Common Names Do not Indicate Common Capacities.—The approach to the solution of the problem cannot be by discussion but must be by experiment. It may be worth while to point out, however, in the beginning that the assumption upon which the popular belief is founded is that a man has a number of single capacities or functions, generally known as faculties which have each a single action, that exercise of the faculty in any way will train it as a whole so that any activity of any kind will run the easier because of the previous activity or training. The analogy is from the parts of the physical body. One knows that any exercise of the muscles of the arm will make the arm stronger. It matters not whether the work done be pitching hay or throwing a base ball, the strength of the arm is increased in proportion to the amount of work and with no reference to the kind.

This popular belief, modern psychology would reject. Memory is certainly not a single and isolated faculty, it certainly has no single member or tool that is used in all the different processes that we call remembering or activities of memory. It is rather a single name applied to a number of functions which have some elements in common. The organ of memory, if there is any, is widely extended through the cortical structures of the brain. On the physical side there is probably little common tissue involved in remembering the name of a king of England and in remembering a base ball score. They may be almost as much separated as small toe and little

finger. So to assume that one would remember a base ball score better for learning the series of kings of England is like arguing that one could train the little finger by moving the small toe.

No Evidence of Memory Training in James' Experiment.—Particular facts cannot be argued from general statements, so psychologists have devoted a great amount of time to testing the actual facts, both for the existence of these cross effects and in measuring the amount of the influence if any there may be. One of the first experiments was made by Professor James. He was appealed to by a man who had been given a series of exercises by an individual who professed to be able to improve the memory in general by specific exercises. James thought he would put the matter to a test. He first learned one sort of material, then spent a number of hours on different days practicing on another type of material, and then came back to the material like the test material to determine if he could learn it any more readily after the long practice series. His results were entirely negative. He learned no better after than before.

Some Improvement Found by Meumann.—A more extended test led Meumann to the opposite conclusion. Meumann's work consisted in having a number of students, some in schools and some graduate students in a university, take tests on learning one kind of material, say poetry; then have them practice for weeks, sometimes even months, daily learning nonsense material, and then take another test on learning poetry of the same degree of difficulty as the first. He found that there was some degree of improvement, but the improvement was greatest when the matter upon which the subject

was trained was the same as that for which he was tested. Learning nonsense syllables, *e. g.*, increases the capacity for learning nonsense syllables from fifty to one hundred per cent measured in the time required for learning, but the improvement in capacity for learning poetry after practice in nonsense syllables would be only from ten to twenty per cent. As a result of his experiments, however, Meumann is convinced that training memory is a very real possibility and even recommends that the schools increase the amount of rote memory work required that they may improve the memories of their students.

Later Workers Believe Training is in Test Series.— Other workers since Meumann are much less assured of this result. Dearborn repeated his experiments with one more check. He believed that most of the improvement in the ability of the man to learn the test material came from the training in learning the first test matter rather than from the practice series. To test this he had a number of control workers, who did the test series alone without the practice, to compare with the individuals who did both the test and the practice series. The results confirmed his suspicions in considerable degree. There was almost as much improvement in the individuals who took the tests without training as in those who did the training work as well. His results would show something like ten per cent or less as the improvement due to learning something else, as compared with more than twice as much for Meumann.

Still more recently Reed has repeated Dearborn's work and confirms it on a larger number of subjects who devoted more time both to the practice and to the tests.

Winch worked in England on school children using as a test the memory span, *i. e.*, the number of digits that could be repeated when they had been read through once. They were trained on learning the sense material of an ordinary lesson, and then were tested again at the end of the series of practice. In his conclusions Winch agrees with Meumann that memory as such can be trained. For his results showed that learning continuous sense material improved the immediate retention or the memory span.

Sleight Explains all as Due to Formation of Simple Habits.—A careful and extended study by Sleight in three English schools showed a still smaller effect of training upon material other than the material in which practice was given. Classes were divided into four groups of equal intelligence. Tests of ability to learn different types of material were given to three. One group was then trained in learning poetry for thirty minutes, four days a week for three weeks, another in learning tables and a third in learning the substance of prose selections. Then all four were again given the original tests. Again all were practiced for another period of three weeks as before and given another test. In one school a fourth test was made after a month to test permanence of the effects with no special practice in memory work, and in another after six months.

Sleight found no appreciable effects from the spread of training. Most of the improvement was due to the training incidental to the tests as was shown by the approximately equal amount of improvement in the untrained subjects. He was particularly struck by the slight differences between two sorts of material that

would prevent transfer of improvement. He trained one group in learning tables of numbers in the expectation that it would improve memory for dates, but found, on the contrary, that dates were learned less readily after, than before. On the whole the effect of practice in a particular kind of learning in improving that special function is much greater than the effect of practice upon any other kind of material. He estimated that one period spent in practice on one type of material, nonsense syllables, *e. g.*, is as effective as four hundred periods spent in another kind, learning prose, *e. g.*, so far as improving ability to learn the nonsense syllables goes. He also found that improvement in training the function actually tested persisted very much longer than the indirect improvement, due to learning another type of material.

No Training of a General Memory.—In evaluating all of these results we must take into consideration both the learning processes themselves and the other factors which are involved in learning. In learning one must pay attention to the material to be learned in a way that may be very different from that involved in the usual learning. This holds particularly of learning under laboratory conditions which may be very different from those of ordinary reading. Thus in learning nonsense material for the first time in the laboratory, the student is disturbed by the instruments used to make the exposures, possibly also by the general newness of the situation. He also finds it difficult to pay attention to a material that has no meaning whatever. Again the mechanical conditions of holding these impressions in mind are different from those which are used for the

ideas of his books or conversation. He must learn to pay attention in new ways, to each letter, and then usually finds it desirable to make more use of detailed imagery than he does in everyday life. The ability to attend to material of this kind grows with practice. All this with the general habituation to the new conditions will improve the capacity for learning material of this type very much in a relatively short time. Now a large part of the improvement in the capacity for learning other kinds of material as a result of practice comes in the training of these incidental processes,—in acquiring habits of attention, in learning to make more adequate use of imagery for difficult tasks of memory, and in other incidentals of the same sort that have not so far been carefully worked out. All this may have little or no bearing on the desirability of memory training in the schools, but it does bear upon the psychological discussion as to whether there is a specific capacity of memory that can be trained. The answer that is all but universally given to this question is "no."

Rote Memory vs. Memory of Ideas.—As to the practical question of the value of formal training in memory in the school curriculum, the answer is possibly not quite so clear. If one means the development of rote memory, it seems probable that there is little to be gained in increasing the amount of practice in that. The modern tendency to reduce learning by rote to a minimum has probably resulted in an improvement over the schools of a century ago in which it was much more emphasized. In the first place there are obviously two distinct and different ways of learning: learning by rote and learning ideas. Observation shows that a habit of learning by

rote does not improve ability to learn the sense itself. The habits required for rote learning are not the same as those involved in the acquirement and retention of ideas. Emphasis on the rote processes which alone can be said to be neglected in the schools to-day, would probably lead to neglect of memory of the content. This is not necessarily true as one can develop two such habits and keep them apart, but unless great care is used to emphasize them both equally and to make sure of control, the tendency to develop one at the expense of the other is considerable. It should be added, too, that training by rote learning of one type of material does not necessarily improve the capacity for learning material of another type. Training on learning history by rote, for example, would not aid in remembering faces, would probably not aid in learning lists of articles for sale in a shop, and might even prevent one from paying attention to the ideas in the passages that were learned. Again practice for a particular kind of material is so quickly gained when occasion arises that it is not worth while to train for it in advance.

Should Acquire Best Habits of Learning.—Memory of ideas is certainly sufficiently emphasized in all school work. In many cases school training is little else. One should also notice that remembering ideas involves a considerable amount of discrimination which is akin to and even fundamental in reasoning. There is always the tendency for perfect rote learning, even for the sufficiently adequate rote learning, to replace thought. One should undoubtedly spend more time in developing the best methods of learning both by rote and logically that the student may spend his time to advantage.

This has been too much neglected all through the school system, partly from lack of knowledge on the part of the teacher. The child, particularly the younger child, cannot avoid doing as much rote work as is required for training for work of that type in later life. Certainly, memory is being more and more replaced by artificial aids and something is to be said for teaching the individual to rely upon them for the more detailed facts.

On the whole, then, arbitrary training of memory would be of learning and recall under artificial conditions. In part, the results of such training could be expected to transfer to the learning of the ordinary conditions of life, and in part they would be kept as things apart. What can be done is to train the child to use the best methods of learning in his regular work. In so far as this is reading, the same methods can be applied throughout life, and the other aids which may be peculiar to the school life will benefit him throughout all of the remainder of his school career.

In brief, then, one can train an individual to remember better one kind of material, and under one set of conditions. In some degree the effects of that training will transfer to other kinds of material learned under different conditions, but the more different the material and the more different the conditions, the less the transfer. Between rote and meaningful learning there is little transfer. In fact, in school work, it seems that there may be opposition between the two methods to the extent that training in rote material may be disadvantageous for learning meaningful material, and practice in learning meaningful material may prove a disadvantage in the training of rote memory.

The Transfer of Training in General.—People believe not merely that one can train memory but can also train judgment, reasoning, capacity for attending, or perception, and practically any other function. Attempts have been made by psychologists to test the accuracy of these beliefs with reference to many different types of processes upon numerous different kinds of material. The experiments are all performed in much the same way. Groups of individuals are given a test in exercising one function upon one type of material; then are trained in another function, and then tested again in the first. They are tested, e. g., in comparing the lengths of lines, then are trained for a period in making similar comparisons of squares or other figures and then are tested again after the training in making the same test of lines as at first. If after training they show improvement over the original test it is assumed that the training has transferred. To be strictly accurate, a second group of subjects of equal ability with the first should be given the test at the same time as the first and then tested again without training. The measure of training would then be the difference between the improvement of the untrained as compared with the trained group. This precaution is taken because the first test alone gives a certain amount of training and this may be mistaken for the effect of the work in the other comparisons as was seen above.

Estimation of Length and Area Shows Little Improvement from Transfer.—We can give only typical results from experiments. Thorndike and Woodworth had individuals practice the estimation of areas of rectangles from 10–100 square cms. until they showed a marked improvement. They then tested them again

on areas of the same size but of different shape, and found the improvement was only 44% as great as for the areas on which they were practiced; for areas of the same shape but from 140–400 sq. cms. in area the improvement was only 30%. Training in estimating lines 0.5–1.5 in. in length gave no improvement in the estimation of lines 6–12 inches long. Training in marking words containing " e " and " s " gave a certain amount of increase in speed and accuracy in marking words containing those letters. The ability to mark words containing other combinations of letters was improved only 39% as much. They had no control experiments so that part of the improvement might have been due to the training in the original test series.

Little Betterment in Estimation of Tones after Practice with Colors.—Bennett experimented on the improvement that might result in discriminating different colors, shades and musical tones from training in comparing shades of blue. The improvement in the discrimination of colors ranged from 56% to 84%, while improvement in discrimination of tones was only 23% and 28% for different groups. Coover and Angell also found a slight improvement in discriminating differences in brightness after training in discrimination of tones. The trained subjects made 59% of right judgments before and 66% after, while the untrained subjects dropped from 65% in the first test to 62% after. This drop would indicate that the average error or the difference due to chance was nearly as great as the apparent improvement.

Improvement May Come from Formulation of General Rule.—On the whole it seems that there is little

improvement in one function from training in a closely related function. Discrimination of one kind of material is not very much improved by practice in discriminating another, and the improvement is more marked when the material discriminated is the more similar. Studies by Judd and by Wang give an indication of the way in which we may explain how the improvement that is found may occur. Judd trained boys to hit with a dart, a target under twelve inches of water. During the training he taught one group the laws of refraction of light, the other he left to learn by the testing itself,—by trial and error alone. He found that the one group learned about as quickly as the other. Then he changed the depth to four inches. He found then that the boys who had been given the theoretical explanation improved at the new depth very quickly, while the boys without any theory were very much confused and showed no indication that the previous training had helped them at all. It was the theory that had been established in one connection that made possible improvement in the other.

Habit of Delay May Aid.—Wang found another simple habit which transferred from discrimination of one type to material of another kind. He used school children as his subjects and first tested two groups for discrimination of colors and tones. He then trained one group to discriminate lines of different lengths until they showed considerable improvement. After this training was completed, he tested both groups again for accuracy in discriminating colors and tones and found that the group with training on discriminating lines had improved very noticeably, while the other had made slight improvement or none. When he sought an explanation,

he found a cue in the time used in making judgments. In acquiring skill in comparing the lengths of line the children had formed the habit of waiting an appreciable time before they passed their judgment. This he determined definitely by measuring with a chronoscope the time that elapsed between the showing of the lines and speaking the judgment. He found that when these children came to the second tests in comparing colors, they also waited to be sure of the judgment before they spoke. What transferred was a simple habit, the habit of making sure before speaking.

Facts Ambiguous.—If we summarize the results of all of the experiments, we find that, nearly always, training in one operation will improve the capacity in related operations in some degree, but in a much less degree, than in the operation practiced. What operations are related can be determined only by a study of the results of these experiments and not by any *a priori* principle. Sometimes, as in Sleight's effect of learning tables upon memory for dates, with two functions that seem alike, training one decreases the efficiency of the other. In all cases, after precautions have been taken to eliminate sources of error the effect due to transfer is relatively small.

Specific Habits May be Applied in New Contexts.—The interpretation of the results is still subject to considerable controversy. A few men hold and more have held that the result indicates that there is no transfer of training whatsoever. That is when the same function is involved in the two operations it will be improved just because a habit will be formed when the identical tissues are used in the two cases. If, however, the two processes

do not involve the use of exactly the same capacities or even of the same neural structures, no change can be expected. Others interpret the results to mean that when the functions or capacities are exercised in any connection they are strengthened in all. The one would practically deny that any training in education would do more than improve the specific capacity involved. To study mathematics would do no more than teach the individual the specific mathematical operations. It would teach him to solve problems in geometry, give him the material that he needed in surveying or astronomy but would have no effect in making him a good citizen or in enabling him to think straight on the tariff or the problems of taxation and labor. The other school would hold that any training in any one field would improve the man in all respects. He would be able to think better on all topics for the training he had had.

The results actually obtained are ambiguous as regards the solution of these broad problems. What they really mean can be understood only from an attempt to determine what one can mean by function or capacity, and an attempt to make clear to ourselves just how the capacity is limited. This is the more difficult since we do not have any way of isolating the functions one from another except by the indirect means afforded by these and similar experiments.

Evidence for More General Functions Slight.—Whether there are definite capacities in addition to these functions of specific parts of the nervous system, we have no means of knowing. The names that we use grew up popularly to describe things that can be accomplished in the world. Like all popular names they were chosen

to suit the convenience of the people who chanced to use them. It is by no means assured that they are used even with a moderate degree of consistency by the same person, and they give no warrant whatever that there are any real forces or functions as separate as the different kinds of atoms named as elements by the chemist, or different forces given separate names by the physicist.

Functions May be Isolated by Study of Correlations.—What is needed before we can fully solve the problem of transfer is full and complete agreement as to what the fundamental capacities may be, if there are fundamentally distinct capacities. Mere popular discussion based on opinion or tradition as to what are the fundamental capacities could never be expected to solve the problem. Indirectly two methods have been used in the attempt to come to close quarters with the question. One has been by the method of correlations. A number of individuals are submitted to different tests and the degree to which they show the same relative standing in different tests, the degree to which a man who stands well in one test shows a tendency to stand high in another test as measured by the coefficient of correlation, is used as a measure of the degree to which the tests may be regarded as the expression of the same or different capacities. Thus if four tests showed a mutual intercorrelation with each other that was high and a relatively low correlation with all others, it would be good evidence that these four were the expression of the same function. One might still ask whether that function coincided with any of the functions given a name in ordinary usage, or as to which of the names might be applied, but it would serve to indicate that there might be a single function involved.

Some Positive Correlation between all Tests.—While this method has been applied it has not given results that suffice to group capacities even in terms of the rough tests that might be used. The usual result is to indicate that there is some relation between all of the tests in ordinary use. Some are closely related, some much more loosely, but with the exception of some few that show negative correlations there is always a tendency for a man who is above average in one to be above in another also. At least, even the standard tests have not given results that will hold accurately enough from test to test to serve as a basis for the determination of minor capacities, using as the measure of capacities nothing more than the ability to do well in the test. Enough has been done to indicate that fundamental capacities do not correspond accurately to our present terminology.

The other empirical method of determining fundamental capacities and the relation of standard tests would be the one we are now considering for the degree in which training is transferred. Those tests for which practice in one induces improvement in another would be put in the same class, while those in which training in one has no effect upon the other would be referred to different classes. As has been said the results of the experiments so far conducted are not sufficiently consistent to permit any definite inference as to the way these capacities are to be arranged. In any case it would be arguing in a circle so far as our present purpose of interpreting the results is concerned.

The net result then of our attempt to define capacity would be to leave us with the name of a capacity as merely a word that designates ability of the individual

as a whole to do a certain thing. This ability depends upon the nervous system, but since we do not know, in most cases, what part of the nervous system is involved, we are not much aided. If we attempt to think of this as a mental capacity in somewhat vague form, we can make little progress in its definition. The capacity cannot be distinguished as cause from its effect. The effect alone is known. If we accept capacity in a general sense and ask how many there are, we do not advance very far, because we have no way of determining their number or mutual relation. All that we can do is to take the names popularly given to capacities and apply in the particular case the name with which popular usage most frequently associates that test and see how one test or activity influences another.

Transfer May Be by Improvement of a Common Habit.—Using our terms in this loose way we come back to the question with which we started, in what way can we explain the improvement in one function through drill in another. The first possibility is that the same knowledge or the same movements or structures may have been involved in both. That would require no explanation other than the general improvement through use which is at the basis of habit. If one learns one fact in one connection, it is no mystery that that fact should improve the capacity in a function in which the knowledge might be applied directly. In certain cases we can go beyond this and see that there are common elements which are not so obvious nor so central. In some cases a habit may be common to two activities that seem unrelated. The habit of reading material to be learned from a revolving drum may be acquired in one type of

material and applied to another. Possibly, even habits of persistence may be acquired in one experiment and applied in all others to the advantage of accomplishment. Becoming habituated to one type of apparatus may help all experiments that are made with that apparatus, no matter how different in character. Working in one place or at one time may lead to the expectation that one will work well in that place and so increase the amount of work done. These effects may be the results of training in one connection that will improve capacity in another however dissimilar the two tasks may be in themselves. Whether one would think of them as transfer of training is another question.

The experiments of Wang and Judd gave evidence of two habits that were responsible for the improvement of one function or of one application of a function as a result of training in another. Learning to wait before deciding would not be regarded as at all a central part of the function of judging, but it was responsible for much if not all of the improvement in judging colors as a result of training in judging lines. Judd's transfer of the effects of learning the general principles of refraction is more fundamental. It is probably representative of one value of an education in general. All education involves learning the general principles, and the tendency to transfer one acquired in one connection to a similar connection is a possible effect of any learning in which the principle is enforced.

In both of these cases the cause of the improvement is to be found in the development of a habit which is used in both cases or in the development or appreciation of a bit of knowledge which may be used in each

operation. There is almost no evidence of training of a common function which can be regarded as covering both different operations. If we generalize this statement it would be seen to be in harmony with general psychological principles and at the same time explain what transfer is proved to occur. We may assume that, even where there can be found no simple element or factor which is common to both of the processes that are trained, we may assume that there are such processes which transfer from one case to another even if they seem to be little alike. This element is improved by the first practice and then becomes generalized and used in all similar operations.

Transfer not Evidence of Training a Common Faculty.—We find, then, every reason to believe that all transfer is not a transfer from one capacity to an altogether different one or even the influence of the work upon a unit factor, or single capacity, but simply the formation of some beneficial habit, habit of perseverance, or of carefulness, or of allowing one's self full time for a judgment, a habit which transfers automatically to all processes which are seen to be similar, and which because they are similar come to be designated by the same name. In this sense the similarity of the two operations may be regarded as at once the occasion for their having a common name and for the transfer, but it is not a case of training a general function which is improved by practice and can be used to better advantage in some other connection because of that improvement.

Evidence of Improvement from School Subjects.—The more practical questions as to what change different subjects in the school curriculum make in the individ-

ual has also been investigated by different men. The results are not very different from those obtained in more abstract tests. One of the most contested points concerns the effect of training in Latin upon the general capacity. This has been emphasized by the change in the recognition given Latin in the educational world during the last two generations and the warmth of the defense of the subject by its skillful advocates. A number of studies have been made of the differences in the capacity of students with a training in Latin and those without it. The problem is complicated here by the fact, accepted by all investigators, that the students who take Latin are, on the average, noticeably more intelligent than the others. It has a reputation as a difficult subject and only the better students attempt it. If poorer students enter, they soon drop out.

Improvement from Classics Largely Specific.—After allowance is made for the difference in natural ability, the effects of training in Latin are not very marked. The student in Latin has higher marks in grammar. This is due to the fact that the English grammar is largely borrowed from the Latin and many of its rules and principles would never have been formulated as they are were it not for the influence of the Latin. The students of Latin also have a considerably larger vocabulary than the non-Latin group, because so many of the English words are derived from the Latin. They also do considerably better work in the romance languages where the words and general language structure are definitely derived from the Latin. There is a slight but noticeable advantage in the study of other languages. On the whole it is possible to state the difference as due to the actual

knowledge acquired in the Latin and in habits of study rather than in the increase of a more general capacity.

Biology Trains Observation Primarily for Living Material.—Miss Hewins made a test to determine the effects of studies in biology upon observation in general. Her results indicate that students tested before and after a ten-day period of training in biological observation improve much more than a section of the same class who spent the same time studying biology from a book. The results indicate a considerable improvement (34%) in observations of biological material as compared with about 5% with non-biological material. This would indicate that general ability to observe is not improved by training, while ability to observe the sort of material for which one has been trained is noticeably increased.

Descriptive Geometry Benefits Geometric Capacities Most.—Rugg made a careful study of the effects of a semester's training in descriptive geometry upon capacity for division, building words, visual imagination of forms, and geometrical thinking. Students who were taking dissimilar courses were chosen for comparison. It was found that there was a considerable gain in the word-building test and in visual imagination and a marked increase (48.5%) in solving geometrical problems. The more similar the capacity tested to the material of the course the greater was the improvement.

Briggs made a similar study of the effects of the study of formal grammar upon ability to use rules and definitions and upon general reasoning ability in other fields. An exhaustive battery of tests was devised and given to two groups of students. It was given after the first

group had devoted three months to formal grammar while the second spent the time on composition and language. Then the first spent another three months on composition and language while the second studied formal grammar. The tests were given to both again at the end of the second period. The experimenter found no indication that the students had improved in general ability in any way that could be ascribed to the training in grammar.

Reasoning Little Improved by Specific Subjects.—In 1924, Thorndike reported the results of a study on the changes in reasoning capacity as determined by numerous tests of 8500 children before and after a year of ordinary school work and endeavored to relate the changes in reasoning ability to the particular subjects that had been studied. The one evident conclusion was that children who showed themselves to have high intelligence at the beginning improved most during the test year. With reference to the subjects studied, students who had pursued arithmetic and bookkeeping improved most, those who had pursued other subjects even showed a slight decrease, but the differences are so slight that Thorndike believes that he is not warranted in drawing the conclusion that any of the changes are really due to the studies pursued rather than to influences outside of school or to chance factors that lead the more intelligent students to select certain subjects. The more intelligent students improve more than the average and this improvement is ascribed to the subjects.

Evidence for Formal Training Slight.—On the whole, the evidence does not favor the theory that improvement in one function spreads to other even closely related func-

tions. Exactly what shall constitute the same or different functions depends upon many circumstances. Whether one is improved in one respect by training in another depends upon the attitude of the child towards the processes involved, and the degree to which he can be made to see that they are identical. In part it is a voluntary matter of classification. It is hard to lay down any rule. University work in writing for English classes may or may not influence the written exercises in other classes and in letter writing, according as the student takes the same attitude towards his writing in other subjects that he does to his themes. Too often the student does not connect them as the same process. Writing themes is one course, writing exercises in psychology is another and it seldom occurs to him to apply what he has learned in one to the other. Only when he is held responsible for good writing in all of his work will general improvement be noticed, or at least as much improvement as should come from practice.

No Transfer in Same Field at Times.—Quite as good an illustration of the same tendency to have no transfer from the special field of training to the general work is found in penmanship training in the schools. The child seems to make relatively little application of improvement in class to the other general writing. The rigid insistence upon form and method that held sway in penmanship instruction at least until recently, made the penmanship hour one of artistic training. When the child turned to write a letter or to a school exercise there was no time for interest in the form, he wrote as he always had written. There was a minimum of transfer. There is relatively little influence of the methods la-

boriously taught in school upon the writing of the men after leaving school. Courtis, as was said above, found that students who had been taught the arm movement in school did not use it afterwards, even when they earned their living by penmanship. The form of letters taught was also found to have little influence upon the styles of writing in later life. One could not date letters by the Spencerian period or the upright period as old manuscripts are dated by the character of the letters.

These at least show that there are many factors which set a limit to the transfer of training in school subjects, even between fields where the habits that are formed should be identical and where, if transfer existed, there would be no difficulty in explaining why it should occur. The study of the correlation of standing in subjects that seem to have common elements is complicated by the fact referred to often, that an individual who stands well in one subject is likely to stand well in a related one irrespective of training. The results can be made to fit fairly well with either theory, the theory that there is transfer or that there is no transfer. There are also variations between different schools and different teachers in the same school. In some cases one seems to find a marked influence where none would be expected on *a priori* grounds, and again, more usually there is no change in cases where one would expect much.

Another illuminating study on simpler material which gives positive results was of the influence in training in neatness in one subject and noting the effect in related fields. Here the effect was positive. Individuals who improved in neatness in the preparation of laboratory

notebooks showed similar improvement in other written work, where neatness had not been insisted upon.

General Effects of Education.—Acquisition of Specific Facts.—We may now attempt to draw general conclusions in the light of these special studies as to the results that may be expected from education in the improvement of the educated man. First we can be assured that the man who passes through any educational system will acquire a number of facts concerning many different subjects. Some of these facts and general principles, many of them if they be only moderately well selected, will be of actual service to him in his later life. They will provide the general principles that will enable him to profit by particular experiences as Judd's boys did from their practice in hitting a target under water. The facts themselves will also prove of value so far as they are directly applicable in the profession of the man in question. This phase of education need not be dwelt upon for no one would question its value. More doubtful would be the response if one questioned an exponent of the value of education as to the application of so-called useless information. Our exponent might reply that no knowledge is useless, that one can never tell what knowledge will be important at any given time or what new circumstances may arise that will make the useless knowledge of to-day the useful knowledge of to-morrow. To this no absolutely satisfactory objection can be raised, but it is not the line of argument that is ordinarily followed by the protagonist of the value of education in its most general forms. Certainly a university should encourage the investigation of all subjects and if they are investigated a sufficient number

of men should be informed of the general results to be prepared to make practical application of them. In the higher schools there is no reason for questioning the desirability of training in any field no matter how slight the practical value may seem at the moment, although the student should be prepared to find very little practical application for much of his knowledge.

Many Habits Have a General Application.—For the lower school and for the wider influence of learning in its effect upon general capacity, much more is claimed than this. The high school student who is not going to college and the college student who is pursuing subjects foreign to the line of endeavor which will probably absorb him in later life desire to be assured of more than that at some time they may be put into a situation in which this knowledge may be useful. He is in search of something that will increase his earning power, or that will at least make him a more effective individual. To this man, one can say with confidence that the habits of study will prepare the student to learn more easily whatever he must learn. If he has formed the habits of perseverance they will transfer, at least to similar fields. He can expect any habits of neatness to transfer. His ability to use the English language, at least that part of his ability which he has become accustomed to apply outside of the preparation of themes for the English class, will be applicable in all fields. The minor habits of work will stand him in good stead in many places where the similarity between the act in which they are acquired and that to which they are to be applied is considerable. They will more than counterbalance the bad habits or the habits for which he will have no use in his practical work.

Many Simple Functions Depend on Related Knowledge.—In addition to both these effects that actually observed facts make obvious, there are many more indirect effects of knowledge upon the man and his capacity that must be taken into consideration. The study of the control of man's conduct and thought show that most of the higher capacities depend directly upon the effect of accumulated experience upon the control of these wider operations. Even so simple and apparently spontaneous a process as attention is really controlled in large degree by the experiences to which the individual has been subjected. What one shall see depends in part upon the situation in which the individual is placed, but much more upon the knowledge that the individual acquired long before. This is of course cumulative. The reaction upon the situation involves much of the reaction upon previous occasions, and upon the earlier acquired knowledge. One will be interested only in what one already knows something about and in consequence wide knowledge is necessary if one is even to be in a position to learn from the environment in which he is placed. Education should and does provide the individual with knowledge that he could acquire in no other way and hence makes it easy for him to learn what he could not learn without this knowledge.

Understanding and Belief Controlled by Knowledge.—Again, understanding what is seen and, much more, what is read, necessitates that one shall have appropriate knowledge to bring to bear upon the particular material presented. Much of this interpreting knowledge may be acquired from the daily routine of the trade or profession, but much that is valuable will be denied to the man

unless he widen his experience by a more formal education, which shall force him to become acquainted with a body of knowledge beyond his daily contacts. The same may be said of judgments and belief, the two processes which serve to enable him to pass adequately upon the various situations that are presented to him. The adequacy of judgment grows with knowledge, and when a situation or set of facts must be judged for which his habits are not adapted, which lie beyond the ken of his own routine life and the tradition and conventions of his fathers, the wider knowledge ordinarily acquired through an education will naturally come into play. The knowledge to be valuable must be definitely related to the circumstances, but the relation is much less close than the actual knowledge acquired in that connection, than knowledge that would find direct application. The properly educated man then sees what the uneducated man will not, he interprets it as the uneducated man cannot, and he has judgments about situations which lie beyond the capacity of the man who is not trained in that field.

Far be it from the intention of the writer to argue that all knowledge is of equal value, or to enter a plea for a formal discipline of the type in vogue a generation ago. Still it does seem that any knowledge vital enough to retain its place in a curriculum of to-day and to attract students, unless it is bolstered by a claim to being practical or by an appeal to tradition and convention, will have its effect in molding the judgment of the student in ways that are valuable to him and to the community. The facts themselves have an influence upon the man's general reaction to life much wider than

their immediate effects in giving him a useful store of knowledge.

Knowledge for its Own Sake and Pleasure.—Again a plea can be made for education that is based upon the mere joy of knowledge. The sense of power that comes with the gaining of new knowledge, be it useful or useless, adds not a little to make life worth while. The habit of acquiring knowledge just for its own sake with the mere pleasure of satisfied interest is worth all that an education costs in the opinion of the man who has an intellectual interest in life. This, if it did no more than supply a means of passing profitably the leisure time that might otherwise be devoted to vice or wasted frivolously, would probably constitute as good a justification for learning as can be given for the arts of music or painting. It has the advantage also in serving as a justification of knowledge for itself, which will make possible the pursuit of learning that does not promise to be immediately useful, but which in the long run is fairly certain to produce results that will be more important for the race or the community than many of the subjects which seem to be of daily application. In the individual who cannot be expected to make useful contributions himself, either from lack of time and opportunity or from lack of intelligence, this may breed a respect for knowledge that will give him an appreciation of the man who can investigate that will serve to provide opportunities for scholars and scholarship that a crude world devoted to the practical alone would not tolerate.

Selection of the Intelligent through Education.—If, then, we ask what we can expect from education for the child or the man, we can insist upon the value to the

individual of the knowledge that he actually acquires in the course of education. In addition there are many incidental gains. These will probably not permit us to indulge in the loose phrases of reverence for the effects of training that were common in the eulogies of education a generation ago but still form a considerable justification for belief in a general improvement through study. We cannot believe that the intelligence of the populace can be improved by education in a way to constitute the bulwark or salvation of democracy, but we have every reason to believe that in the process of education we shall select from the general mass those competent individuals who are capable of leadership in a democracy and this will make democracy work almost as well as if we could create or sharpen intelligence by our training. We cannot believe, in the light of the experimental evidence, that education improves memory or reasoning by practice, that the use of memory or reason in one field or with one type of material will improve its capacity for all other material or for all other subjects, but we do have evidence that in learning anything one forms habits which may be useful in learning any other material that is not too different from it in kind.

Again we may believe that the knowledge one acquires will give a basis of judging in fields that are related to the one in which the original acquisition was made and that this will influence the opinion and improve the accuracy of judgments in all fields that have anything in common with that one.

Education Should Introduce a Man to the Fellowship of Scholars.—Above all, an education of the right sort

should give a man a confidence in his own opinion, a veneration for knowledge in general, that on the one hand will keep him from being misled by false statements and plausible fallacies and that shall keep him ready to continue his education whenever opportunity affords. The tendency to hold judgment in balance by facts actually acquired and the habit of inquiry where facts are not present, should contribute to make him a good citizen in so far as he judges accurately all matters that bear upon citizenship. While, then, we may have changed the grounds upon which we urge education upon the multitude, the argument in favor of education is as strong as ever. It may be that it will argue for the teaching of subjects that would not have been admitted to the curriculum a generation ago, and may make us inspect the knowledge offered a little more closely to see that it has value for itself as well as for the incidental benefits that are to be derived from it, but this will not materially change the nature of the plea and may increase its appeal.

QUESTIONS ON CHAPTER XV

1. Enumerate the occasions that lead to the use of names for faculties. What are the logical and practical objections?
2. Can you train by exercise in one task a capacity that has the same name? Will learning dates help in learning psychological theory?
3. To what does the problem resolve itself?
4. Describe James' experiments to discover if memory could be trained.
5. How did Meumann's conclusions differ?
6. What new precautions are necessary that Meumann did not recognize?
7. Compare Dearborn's and Sleight's results.
8. State the present status of the problem concerning training

of memory. Would you make an attempt to train memory in the schools?

9. Can you train discrimination as a whole?

10. Could you improve intelligence?

11. Do you find specific improvement of capacities as a result of any school subject?

12. Why do the best students graduate from the classical courses? if true?

13. Is there any evidence that specific change in any capacity is closely connected with the subject studied?

14. List the fallacies that usually creep into arguments about transfer of training.

REFERENCES FOR CHAPTER XV

THORNDIKE: *Educational Psychology.* Vol. II. Chapter 12.
STARCH: *Educational Psychology.* Chapter XIII.
GATES: *Psychology for Students of Education.* Vol. XV.
MEUMANN: *Psychology of Learning*, pp. 347–364.
SLEIGHT: "Memory and Formal Training." *British Journal of Psychology*, Vol. IV, p. 386.

CHAPTER XVI

TESTS OF ACCOMPLISHMENT IN SCHOOL SUBJECTS

We have already indicated in connection with certain of the more important mental operations some of the factors involved in the more prominent school subjects. The others can also be reduced to a few relatively simple processes that have been treated from the psychological side. Arithmetic, *e. g.*, is a process of forming associations between two or more simple numbers and their sums, differences, products, and dividends. In the more advanced stages combinations of these simple associations are involved and reasoning is implied in seeing the relations between the practical situations of life and the abstract associations. Reading is a special application of the laws of perception. Spelling involves memory of a special formal character, and may be closely connected with the individual's memory type. Each of the other subjects involves more or less specific mental laws or combinations of mental laws.

Relatively recently much attention has been given to devising schemes for measuring the attainment in each of these subjects that may be applied to children without reference to the particular type of instruction that has been given. In certain cases these tests involved determining the number of associations that need to be formed to obtain perfect mastery of a subject, and then devise a

method of sampling to discover what percentage of the entire number a given child has formed. Could measurements of this kind be made perfect it would be possible to determine what schools or grades were effective and what children in each grade had profited by the instruction afforded him.

Quantitative and Qualitative Tests.—The tests must have a different purpose and a different character in different subjects. They have sometimes been divided into quantity tests and quality tests. The quantity tests can measure directly how much has been acquired, the quality tests on the other hand must grade the relative skill in different operations. Quantity tests can be used in arithmetic, where the associations involved could be counted and the percentage acquired measured or enumerated; in spelling, where the words in common use may be counted and the percentage known by a given individual determined directly; and in reading where rate and degree of understanding can be measured directly. The quality scales must be applied where what is desired is a degree of skill that does not imply any specific numerical value. Typical of this are penmanship and composition. In both of these cases scales of excellence have been developed on the basis of the average performance of children of different ages or in different grades, and the sample to be graded can be equated to a given sample in the scale. Both quantity and quality scales imply the determination of the average attainment of the children of different grades which must serve as the measure of progress of the individual. A description of the methods that have been applied in the different subjects will prepare the reader for reference to the larger treatises listed

at the end of the chapter where detailed rules for the application of the tests can be found.

SPECIFIC TESTS

Spelling Tests.—One of the simplest measures to apply is of the proficiency in spelling. The material in spelling is simplest and there is no difficulty in scoring. A word is always either right or wrong, save in the few cases where the authorities differ, and these may be dogmatically made to follow the taste of the maker of the test or book. The development of tests of spelling assumes, first, the selection of suitable words for a test. The modern ideal is to have each child learn thoroughly the words that he is certain to use in the work of the grade that he chances to be in, as opposed to the aim of an earlier generation to know all words, particularly the unusual words and words of unexpected combinations. The words chosen for the tests have been selected from material with which the child should be expected to be familiar. Children's essays, business letters, current high-grade magazines and the more classical literature have been analyzed and the words used have been drawn upon for lists to be used both in drill, and in tests of spelling. Most of these lists contain less than four thousand words.

One of the best known lists for test purposes was made up by Ayres. It consists of a thousand words arranged in groups of twenty of increasing difficulty. This may be used first as a test. Twenty to twenty-five words are selected for the test of a grade or of a child. The scale gives the percentage of words in each column or group that should be known by each grade. This percentage

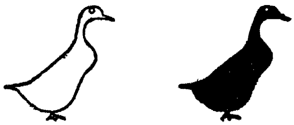
varies for column K from fifty-eight per cent for the second grade to seventy-nine per cent for the third grade and ninety-two per cent for the fourth grade. Various supplementary lists have been added by Buckingham, Courtis, and others, which furnish both tests of attainment and drill material.

In addition to mere determination of the attainment of a child or of a grade, it is possible to measure the effectiveness of different methods of teaching. It is possible, also, to study the mistakes of each student and determine what changes should be introduced to make him learn more readily. Typical problems that have been discussed are the advantages of special drill in spelling as compared with permitting spelling to be acquired incidentally with reading and writing. Two early workers, Rice and Cornman, made studies of the relative progress in spelling of pupils who had long drills and of those who had short and later of those who had no drill. Their results indicated that the amount of time spent in drill had little effect upon the results obtained. Cornman found in certain of the schools in Philadelphia that rooms that had no definite drills spelled as well as those who spent the usual periods. These results do not agree with most of the later work. These show that careful instruction, which first discovers what words are not known and then drills carefully, paying attention to the parts that make difficulty, produce markedly greater improvement than the incidental training in connection with other tasks.

READING

Much the same principle may be applied to reading. If spelling is a process of forming associations between

the sound of a word and the picture of the letters or some other images or general notions that make possible writing the proper series of letters to reproduce the word, reading is a process of forming associations between the sight of the letters that constitute the word and the spoken sounds, or, in silent reading, the meaning of what has been written. Measurement may follow the same



These ducks are out walking on a cold winter day. The black duck is ahead; but she is unhappy because the cold snow hurts her feet. Make one short line under her feet to represent a board for her to stand on. Then make one more short line for the white duck to stand on. Now both ducks will keep their feet warm.

FIG. 29.—A sample passage from the Burgess Reading Test. The whole test consists of 20 passages of this type, all of approximately equal difficulty. This is a "speed" test.

general process. One should determine how many words the children in each grade should read in a given time and the number of mistakes made in standard passages of average difficulty. Incidentally, methods of studying the particular errors of the child can be added, and so an explanation for any defect and suggestions for remedying the particular deficiency formulated.

The rate tests are easily made and individual evaluation of the ability of a child to read aloud may be made in terms of the way the material is interpreted. Even

here, however, numerical results cannot be obtained of comprehension. Various silent reading tests by Monroe, Starch, Gray, and Haggerty among others are alike in using various questions upon the material read as a measure of the degree of comprehension. The method of application varies in detail. Certain, as that devised by Starch, ask merely for a summary of what has been read, others ask explicit questions, and others ask the child to select the correct answer from a number of suggested ones. Each has its own arbitrary scale for grading the result so far as comprehension is concerned. Each also assigns a normal value for each grade both in comprehension and in rate. One can obtain a combined rate and comprehension score for each pupil and for each grade that is of value in assigning the children to different tasks or in determining the value of the teaching.

HISTORY AND GEOGRAPHY TESTS

The method of testing for the subjects which involve mere knowledge of facts and those in which there is room for considerable difference of opinion as to the content that is most important follows the same general principles. Its validity will be limited by the variation in the text-books used. Even these have a value and properly interpreted can be taken at somewhere near the face of the results. This holds especially where comparisons are limited to a school system in which the same texts have been used and approximately the same methods have been followed. Tests of this type have been prepared for both History and Geography. They consist in each case of standardized series of questions of increasing difficulty. Scoring is directly in terms of the

number of questions answered. As answers in these subjects may be partly right the scoring must give part credit where it is deserved. Courtis and Hahn and Lackey have prepared scales for Geography. Harlan, Starch, Bell and McCullum, and von Wagenen have prepared history scales. The history scales have been devised to test, 1, knowledge of facts; 2, ability to think in the interpretation of the results; and 3, a knowledge of character, which throws an indirect light upon the ideals and probably on the character of the student. The individual is scaled on a percentage basis. The median score for the seventh grade on Harlan's scale in American history proved to be 56%, while for the eighth grade it was 86%. This will indicate the range of improvement in one year. There is also a wide scattering of the results, within the grade.

ARITHMETIC

Tests of arithmetic are among the most familiar and were developed among the first. Arithmetic is in essentials a process of forming associations between the several small numbers and their sums, differences, products, and quotients and of combinations of these associations or bonds. The associations are formed by frequent repetition and after the simple bonds are formed, these may be combined in new ways to solve the more complicated problems. After the connections with the more abstract problems have been formed, the child must learn to see these simple operations in the more concrete problems. What we know as arithmetical reasoning consists very largely in referring the actual problems of everyday life to the scheme of the abstract arithmetical computations.

MULTIPLICATION

(1) $3 \times 7 =$	(3) $2 \times 3 =$	(4) $4 \times 8 =$	(5) $\begin{array}{r}23\\ \underline{3}\end{array}$
(8) $\begin{array}{r}50\\ \underline{3}\end{array}$	(9) $\begin{array}{r}254\\ \underline{6}\end{array}$	(11) $\begin{array}{r}1036\\ \underline{8}\end{array}$	(12) $\begin{array}{r}5096\\ \underline{6}\end{array}$
(13) $\begin{array}{r}8754\\ \underline{8}\end{array}$	(16) $\begin{array}{r}7898\\ \underline{9}\end{array}$	(18) $\begin{array}{r}24\\ \underline{234}\end{array}$	(20) $\begin{array}{r}287\\ \underline{.05}\end{array}$
(24) $\begin{array}{r}16\\ \underline{2\frac{5}{8}}\end{array}$	(26) $\begin{array}{r}9742\\ \underline{59}\end{array}$	(27) $\begin{array}{r}6.25\\ \underline{3.2}\end{array}$	(29) $\frac{1}{8} \times 2 =$
(33) $2\frac{1}{2} \times 3\frac{1}{2} =$	(35) $\begin{array}{r}987\frac{3}{4}\\ \underline{25}\end{array}$	(37) $2\frac{1}{4} \times 4\frac{1}{2} \times 1\frac{1}{2} =$	(38) $\begin{array}{r}.0963\frac{1}{8}\\ \underline{984}\end{array}$

FIG. 30.—Short Multiplication Test from Woody.

Scoring Arithmetic Tests.—The arithmetical tests all take much the same form with the main difference between them in the way in which they are scored. The more important tests are the early one of Stone, the more developed of Courtis, and Woody's and Thorndike's arithmetical ladders. All are graded series of problems in each of the more important operations. They are given to large numbers of different grades and so standardized by obtaining the mean accomplishment of the grades. Any given grade can be rated by comparison with the standard. There are certain differences in the way in

which allowance is made for speed and accuracy in the accomplishments. The scoring methods are more elaborate as we proceed from the earlier to later scales, but these may be regarded as differences in details rather than in principle.

Each of the scales also tests the ability of pupils to apply the knowledge learned in the abstract to concrete situations. To this end each sets a series of practical problems and measures the success and speed with which they may be solved. This both measures the knowledge of arithmetical problems, and the ability to resolve the everyday conditions into their elements. It is at least a useful supplement of the first form of scale. (See Figure 30.)

QUALITY SCALES

In the subjects so far discussed, amount of knowledge and speed of response may be regarded as the measure of attainment. If one determines the accuracy of the pupil in a given test and the speed with which an answer is given, one may be said to have all of the significant features of the child's work. In two subjects these are not enough, and are hardly the most significant features. These are penmanship and composition or English where what is quite as important as speed is the quality of the work. It would be difficult or impossible to describe quality in ways that could be measured directly. To obviate this difficulty various scales of quality have been devised for both. The first to be developed was the penmanship scale. Thorndike, Ayres, and others had competent judges arrange samples of handwriting in the order of merit. Combining the judgments of all of

the judges gave a scale that was reproduced of eighteen steps for the Thorndike scale and eight steps for the Ayres scale. Ayres gave three samples of different slant for each quality. His instructions were to compare the given specimen with the scale until a step in the scale was found of the same quality, then if there was time mark it on the back and after all had been graded compare them again, and assign the average of the two ratings. This rating would be combined with the speed to determine the final grade assigned to the specimen. (See Figure 31).

Courtis found if he compared the steps that seemed to be equally different that they were really different by a certain proportion of the amount. This would make it a geometrical-arithmetical relation, similar to that between stimulus and sensation as formulated in Weber's Law.

Rate Increases with Grade.—On the Ayres scale the rate of writing will vary from 32 letters per minute in the second grade to 80 per minute in the eighth grade. The increase for each grade is twelve letters per minute from the second to the third grade, and from the third to the fourth, but drops to eight from the fourth to the fifth and is only six per grade in the next two grades, and the eighth is but four letters faster per minute than the seventh. In each grade there will be wide differences between different pupils. One may expect the fastest to write at least fifty per cent more words per minute than the slowest. The quality will also be widely distributed over the scale in any grade even when the average of the grades corresponds closely to the mean.

Diagnostic Functions of the Tests.—The results of the tests may also be used to correct the faults of the dif-

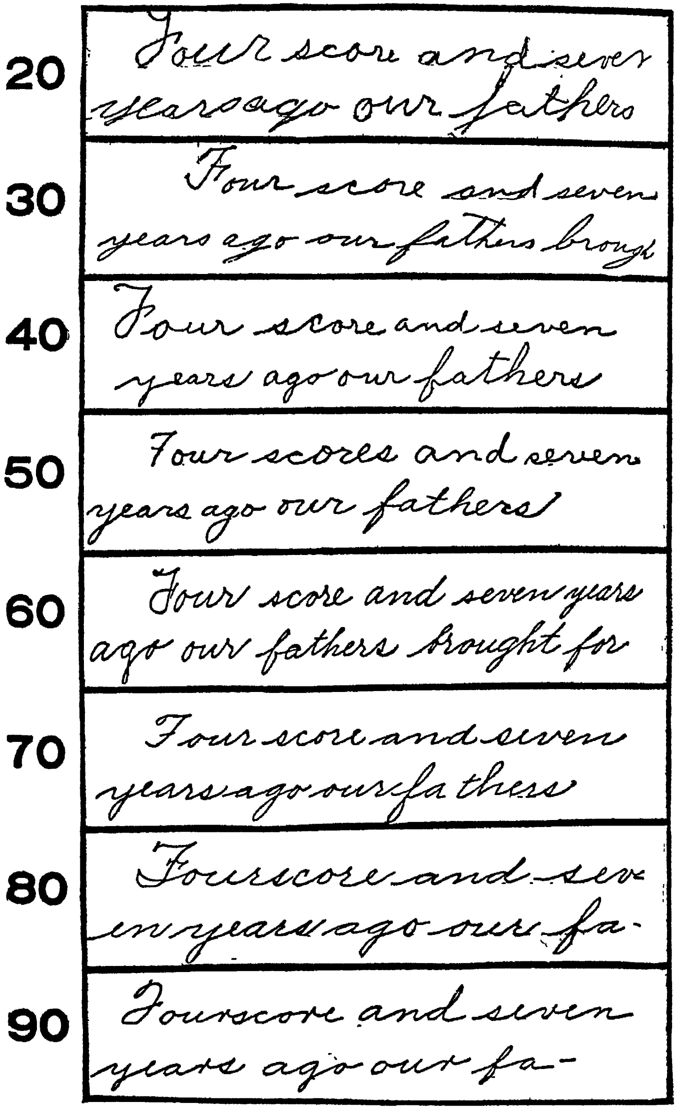


FIG. 31.—Writing Scale. Each sample has the grade placed opposite it. The Russell Sage Foundation Gettysburg Scale, prepared by Leonard Ayres.

ferent pupils. It is easy to say whether a given individual is deficient in quality of writing or in speed. If the quality is defective it is also possible to reach some conclusion as to why it is lacking and even as to the probable cause of the defect. Extreme youth may give lack of muscular control. Or the defect may be an irregularity of slant, or an ugly slant. Pointing out the characteristic that is ugly will give possibility of special practice in the improvement of that feature and may hasten improvement. While the diagnosis is incidental to the measurement, it may be quite as important in its effects. It is also of value to be able to say to a pupil just how bad his writing is. That knowledge will serve as a spur to greater effort if the child is much below standard and will encourage to continued improvement if he stands well in comparison with others of the same age.

ENGLISH COMPOSITION

The scales for composition must also take into consideration two different phases of the process, one purely a quality factor, the matter so called, and one that can be measured, the form of the writing. Quality depends upon the character of the thought to be expressed and the adequacy with which it is expressed. A scale was first developed by Hillegas, which was later extended by Thorndike. Other scales were developed by Ballou, the Harvard-Newton scale by Willing, and by Trabue. The first two are alike in that they arrange samples of composition in order of merit and compare the compositions to be graded with them. The Trabue scale gives a series of sentences of increasing difficulty and asks the pupil to supply missing words in each. It measures flexi-

bility in arousing associates, but how important this is in the attainment of correct English is difficult to say.

Measures of Form in Composition.—The measure of form is in terms of the number of mistakes made per hundred words. Errors in punctuation, misspellings, and grammatical blunders are all counted. The arbitrary values assigned to the story scale for the various grades are as follows: on the Willing scale:

Grade	I	II	III	IV	V	VI	VII	VIII
Story	20	30	40	50	60	70	80	90
Form	30	23	17	14	11	8	5	0

It is suggested that in rating the compositions, all should be read through carefully in comparison with the samples given in the scale and assigned to one pile for each scale. This should be recorded. At another sitting, preferably, all should be graded again without noting the first. Where there is agreement the rating may be accepted as final. Where there is disagreement, the cases should be considered carefully to determine the occasion for the difference.

Diagnostic Value of Scales.—After the scaling has given the relative skill in composition, careful consideration of the results should indicate the special deficiencies of the individual pupils and the methods of training to be recommended to each. Good English demands immediate association between the idea that is passing through the mind and the appropriate words. This must be checked by a good taste, that will detect and reject before utterance any departures from accepted form. The first requisite is something to say. This demands experience of interesting events or acquaintance with

good literature or both. It also demands sufficient intelligence to know what is interesting and to see it in a new way. This intelligence is largely native and cannot be increased. Something may be done at times to encourage individuals to express the natural reactions that are more worthy than they believe them to be.

Imitation of Good Models Essential to Proper Writing.—Good taste in appreciation and correct and fluent speech can be most readily developed by having none but good models for the child in reading and in speech. The school can provide this only in the measure that the children come from cultivated homes. The authorities can insure good models from teachers and others, but this is but a beginning, and may easily be counteracted by the language heard from the other children. Constant practice in writing that permits no exceptions of bad writing or speech in any school exercise will do something. Constant reading of good literature should in time establish good taste and that may be translated into good habits by unremitting repetition.

Formal Grammar of Little Value.—Formal training in rules of grammar may be of value in giving criteria for rejection of suggested combinations, but modern tests show it to have less importance than the place assigned it by the older teachers would suggest. A good vocabulary comes with reading, provided careful attention is paid to the meaning of new words, and special effort given to use the most effective of them as their meanings are learned. Again knowledge must come first and the knowledge then be translated into habit. Possibly even more depends upon the skill and initiative of the teacher in composition than upon the method used. The differ-

ence between children of the same intelligence and approximately the same home environment, who are taught by different teachers is even greater than in other subjects. The pupils of one room of the same grade may average twice as high as those of another. Lack of other reasons for the difference at least raises a presumption that the cause is to be found in the greater interest aroused by the one teacher and the consequent greater incentive to practice, granted that the methods and knowledge are equal.

Tests for High School Subjects.—There is no reason why similar standard tests might not be developed for the high school subjects or even for the university subjects that have become highly standardized as to content and method. Monroe, Rogers, and Hotz have developed tests for algebra. Haggerty has suggested tests for high school reading. They might readily be formulated and standardized for the ancient and modern languages, geometry, and the elementary sciences.

Scales are Measures, not Material for Drills.—It might be questioned whether an extension of these tests might not tend to too great mechanization of teaching. This need not be the case. The tests do not determine the character of the teaching, but only measure its effects. Occasionally we hear of a teacher using the tests as a means of drill. This is not in harmony with the spirit of the tests and would nullify the effects of the test if persisted in. The tests really have the same purpose as an examination. They are to be regarded as standardized examinations, which will enable an examiner to compare pupils of different schools and different trainings fairly.

Results of Scales of Value for Vocational Guidance.— The general diagnostic value of the tests may be made very great. If the pupils of a school had in the common books a record of their success in a series of these tests for each subject, together with the results of an intelligence test, and a rating by various instructors of his emotional and voluntary characteristics, it is obvious that advice of a social and practical nature would be very much more effective than the haphazard opinions of single instructors who might interest themselves in the cases. The measurements also would have value in determining the relative ability of teachers for different subjects. The results might be used to encourage teachers to take special training in subjects in which their pupils were shown by the tests not to do well. Many other administrative uses suggest themselves.

The intercorrelation of the standing of pupils in the different subjects and the correlations of the standing in the subjects with the results of the intelligence tests are interesting as an indication of the adequacy of both measurements. There is a positive correlation between the measurements of the standing in all of the subjects and also with the mental age or intelligence quotient. Gates gives the intercorrelation for the standing in the standard tests in different subjects as ranging from 0.33 between spelling and arithmetic as determined by difficulty to 0.52 between spelling and reading and between reading and composition. The table follows:

	Reading	*Arithmetic Difficulty*	*Arithmetic Facility*	*Composition*	*Spelling*
Reading		.48	.44	.52	.48
Arithmetic Difficulty	.48		.65	.43	.33
Arithmetic Facility	.44	.65		.42	.36
Composition	.52	.43	.42		.52
Spelling	.48	.33	36	.52	

In this table the measure of the difficulty in arithmetic is the most difficult problem in the Woody scale that each pupil could solve. The facility test uses the number of problems of equal difficulty that each pupil could solve as its measure. That the two are related but still measure different capacities or give different indications of the same capacity is evident from the fact that there is a correlation of only .65 between the two measurements.

The correlation between the results of educational tests and Binet-Simon tests were found by Burt with three hundred children to be very close for the more abstract subjects and much less for the more mechanical. Between intelligence and composition the coefficient of correlation was 0.63, intelligence with reading, 0.54; with dictation, 0.52; with arithmetic problems, 0.55; with arithmetic, mechanical, 0.41; with writing, 0.21; with drawing, 0.15; with handwork, 0.18. This would indicate that progress in school subjects depends more than anything else upon native ability. On the other side, Burt uses it as evidence that ability to pass the Binet-Simon tests also depends upon scholastic instruction in considerable degree.

QUESTIONS ON CHAPTER XVI

1. Enumerate the aim of tests of accomplishment in school subjects.
2. Outline a scheme for the development of a spelling test.
3. Give the characteristic differences in the more important ones.
4. What two factors must be measured in a reading test? How develop numerical standards?
5. Give the principles of an arithmetic test.
6. How many problems are necessary to constitute a fair sample?
7. Give the essential differences between an arithmetic and a writing test.
8. How could one prepare a writing scale?
9. Illustrate the method of measuring ability in English.
10. What can you learn of a school system by the application of the tests?

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